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SYMPOSIUM ON THE PURPOSE AND ORGANIZATION OF PHYSICS TEACHING IN SECONDARY SCHOOLS.

(Continued from December, 1908.)

VII. BY PRESIDENT G. STANLEY HALL.

Clark University, Worcester, Mass.

My ideas about the reorganization of physics in the secondary schools of this country are motivated by the lamentable results which I have always associated in my mind with the report of the Committee of Ten. Many colleges in the East practically agreed upon selecting physics as the typical science which should be taught in preparatory schools where no other science had yet found a footing. They felt that if work in this department was done in a way to justify itself this would open the way for other sciences in the smaller fitting schools where the classical ideas had hitherto predominated. This movement for the reconstruction of physics came at a very unique moment in our educational history. Mathematics had come to be more and more the language of this science in academic grades, and at the same time we were at the very apex of the way of "universitizing" not only the college but even the high school. Narrow but acutely trained specialists as in other departments from Europe and the Johns Hopkins and other institutions were coming to be heads of physics departments to the exclusion of the old descriptive physics of the Ganot type. Under these circumstances it is not surprising that the courses of lessons given in the high school and text-books on this subject were too abstract; the course was too logical and mathematical and not enough descriptive.

What has been the result? The statistics show that physics has been taken by a less and less percentage of our high school pupils for the past ten years. The great majority of even the male pupils in our high schools never touch it despite the great emphasis, the abundant credits, the special equipments pro-

vided. It is the old story of James Russell Lowell's eider duck farm, the proprietors of which had demonstrated chemically that nothing would make duck flesh so rapidly and so exquisitely palatable as celery and so a vast establishment was equipped for the business, and the proprietors found in the end, to use Mr. Lowell's own expression, that "celery was about the only food the durned ducks wouldn't touch." Now what is to be done? My simple prescription is to go back to the nature of the high school boy and doing so we find that if there is any intellectual interest to which he is more devoted than another it is to learn the "go" of things. He pores over the *Scientific American* and likes to watch and understand machinery. Moreover, he has begun to think how he is going to make a living. Therefore let us restore:

1. The old descriptive stage with many experiments illustrated in cuts and in the laboratory, but with but minimum amount of mathematics.

2. Let us bring the utilities to the fore and recognize the fact that genetically applications of science precede the development of pure science, that the true method of education is not first to learn the principles and then to apply them, but to pass from the technique and up through the concrete applications to the pure science itself, allowing thus the practicalities to come first and deploy all their motivation. I am aware that this involves an inversion of previous methods and seems if logically carried out to put the technical school ahead of the university, but for one I accept this implication with all its significant results. I think we have much to learn from the Germans with their many colored wall maps for boys in the early teens illustrating the steam engine, the electric motor, the mechanism of wireless telegraphy, aërial navigation, etc.

3. I would have sifted into the course the most inspiring things from the history of physics, which has been a long and glorious one. Some of the biographicals of some of the great discoverers are admirably calculated to fire interest, which present methods tend to stifle.

4. I would make the course modern and have it touch present life at every possible point. I do not believe there is a high school boy of fifteen or sixteen in the country who ought to be in the school who cannot be made to glow with interest and to get a partial understanding of the very subtlest questions con-

cerning ions, electrons, or the general results of the work of men like J. J. Thompson and Van't Hoff.

5. I have long believed that there is a very precious but as yet almost untouched fuel bed for generating interest in physics in the literature on sleight of hand. I have collected several scores of books and references on this subject for the last ten or fifteen years and I have known a few cases where cheap apparatus of this sort has aroused intense interest in the principles underlying them. In the Argentine Republic I am told in the official course of physics much use is made of this apparatus.

6. And lastly, this leads to the use of toys. The way can be prepared for physics even in the grammar school or lower yet, by a well selected course of toys such as we know little of but which abound in Germany and which illustrated so many of the principles of physics. The proceedings of the various toy congresses are very suggestive along this line.

I believe that it is only by such methods as these that we can rescue secondary physics from the present degradation into which it has fallen by the neglect of simple, common sense pedagogy, which is all the less excusable now that it is reinforced by such a body of studies of the nature and needs of youth.

VIII. By Professor Albert A. Michelson,

The University of Chicago.

It is my belief that the teaching of physics in the high schools might be made far more attractive as well as useful—and especially so for the very large majority of pupils who do not intend to pursue the subject further either for its own sake or as a preparation for scientific or technical training—if less stress were placed upon what has come to be regarded by many as its chief object, namely, the science of measurement.

The fact that most of my own investigations have been in the direction of accurate quantitative work may be taken as an indication of the very high value I place upon this side of scientific education—but I would venture to submit the opinion that not only does the subject when treated in this way defeat its ends by turning away many students—and not by any means the least promising—by presenting a side which to immature minds is certainly not the most interesting.

I would therefore propose—for discussion—the feasibility of a plan for the teaching of physics which avoids as far as possible the use of mathematics even of the most elementary kind —and which gives to the science of measurement only a secondary importance.

The advantages of this innovation seem to me of fundamental importance. In the first place it will be readily conceded that it is more important to know the *nature* of physical relations than to know their exact value.

It is of vastly greater value to know that all bodies attract each other than to know the law of inverse squares; to know that light is produced by a vibratory motion at right angles to the direction of propagation than to be able to calculate its wave length to seven significant figures.

And in my opinion these fundamental facts are not only far easier to teach but are also of immensely greater value in after life—especially to the large class of students who will not pursue the subject further.

As a supplement to such a proposition as the foregoing I would also urge—especially for the benefit of those who do intend to pursue the study of the exact sciences—a thorough drill in the use of mathematics as a tool—which may be made to include mechanical drawing, curve tracing, and especially short methods of obtaining approximately accurate results, as well as the solution of simple problems in mechanics and other branches of physics.

IX. By Professor J. Mark Baldwin,
Johns Hopkins University, Baltimore, Md.

The object of the teaching of physics is the *teaching of physics!*

This general reply to the question set for discussion is not intended either as a mere tautology nor as a bit of disrespect to the problem set. It is rather to be understood as a word of reaction against the tendency to substitute a secondary and remote consideration or result of instruction for the primary and immediate one. What results may conceivably come from the study of physics—results of any degree of importance—these results *assume the physics*: and the teacher gets these results largely in proportion as he *forgets them* and bends his efforts to the *teaching of physics,* pure and simple. Allowing that it is

physics that is to be taught let it be physics that is taught and nothing else. The end in view then—to be pursued by the teacher with a single eye—is this: *that the pupil may know his physics.*

On this basis, I conceive, it is then fair to ask two further questions:

(1) *The question, what physics is to be taught,* and

(2) The question, what is the place of physics in the general pedagogical scheme?

But both of these questions I conceive assume the simple and straight teaching of *physics* as such by the best methods.

As to these two questions, I am not expert enough in physics to discuss the first and I have neither space nor time to treat the second. So the burden of my reply is: let the teacher teach physics as such, not allowing the pedagogical philosophy which justifies his subject to blind him to the importance of this first and simple task.

X. By George R. Twiss,

High School Visitor, Ohio State University, Columbus, Ohio.

The aim of all teaching is to assist the student in gaining insight into the manifold processes of his environment and efficiency in reacting to them and operating successfully among them. The end is right conduct; hence "education is not merely a preparation for life: it is life." Each of the activities of the modern school is justified in proportion as it contributes effectively to the end that the students may have life and have it more abundantly.

It has been shown that the training that makes for insight and efficiency in any subject clings to the content; this must be selected to have appreciable significance to the student. Such significance cannot be given him by cramming his memory with words and mathematical symbols, nor by requiring him merely to state laws, derive equations, and determine physical constants; but rather by setting him to solving problems of his own is the way in which the scientist solves his problems. The student will not react to the phenomena themselves, but rather to the personality of the teacher or the printed page, unless the problem in hand appeals to him personally as one whose solution is worth sustained effort to him. Physics teems with such problems.

The work in physics will not be effective until physics teachers understand that their business is not to "teach physics," nor yet "by fair means or foul to get the pupils to learn as much as is contained in ——— ———'s text-book," regarding all topics as of equal importance, because any one of them may appear in a college entrance examination. We must rather come to know that we are part of an extensive system of educating children. Since the study of physics is thus a means of education and not an end in itself, the subject matter should be chosen both in amount and character with reference to the needs of the pupil's growing minds rather than with reference to its logical place in an abstract and highly developed scheme for presenting "a comprehensive view of the facts and laws of elementary physics." If the teacher limits his teaching to the mere acquisition of subject matter on the part of the pupil, he is simply cramming the victim with facts—or worse still, with theories which the pupil accepts as facts—which the pupil knows not how to use, either in acquiring other knowledge or in guiding action. On the other hand, if the teacher makes the work to consist in defining and solving some of the problems which naturally arise in connection with the physical phenomena with which the pupils are surrounded and in which they are interested and about which many of them already have some knowledge, he will have the first and fundamental condition of education, namely, self-active motive and sustained attention.

If we are to improve the teaching of physics, we must attend to the following things:

1. Cut the required subject matter to something which in common sense and reason, high school students, not teachers, may be expected to digest and thoroughly assimilate.

2. Do not drill interminably nor examine on dynes, ergs, poundals, Newton's laws of motion, the laws of falling bodies, and other abstract matters which twenty-five years of experience all over the country have shown that pupils of high school age cannot comprehend and apply.

3. Confine questions in college entrance examinations not only to "fundamentals," but to those particular fundamentals which sane and experienced secondary school teachers have learned that their students can master.

4. Discourage the perfunctory use of formulas. These should be used only when the student appreciates them as con-

venient abbreviations for statements whose content he clearly grasps and understands.

5. Teach by and through the scientific method, and study the setting up and the evaluation of the problems with reference to human relations that appeal to the student.

6. Insist on thorough mastery of a reasonable amount of a reasonable kind of fundamentals, but do not try to cover with equal thoroughness all the material in any text-book.

7. As far as circumstances will admit, use the historical order of development, and bring out the humanistic relations by biographical material and relations with commerce and industry whenever such means are available.

8. Communities must be trained to see that they must pay at least the market price for trained science teachers. In many of the smaller schools the science teacher is the weakest in the corps, and receives from $600 to $900 per year. The supply, at such a price, of people who know enough of the science and the proper methods of teaching it to be able to do good work is very small in proportion to the demand. The result is that in smaller schools the position of science teacher is usually filled by someone who is really incompetent to teach science.

Most people do not realize the great inconvenience to which the Post Office Department of our government is put by the daily receipt of over 40,000 pieces of mail matter, a large portion of which is improperly addressed. Would it not be well for instructors in all subjects to call attention once in a while to the proper way of addressing an envelope? Here is an order from the Postmaster-General which is not generally known:

Office of the Postmaster-General,
Washington, D. C., Sept. 18, 1908.

Order No. 1742.

Postmasters are hereby directed to confer with their local school authorities with the view of adopting the most effective method of instructing school children as to the organization and operations of the postal service. These instructions should cover such features of the service as the delivery of the mails, the classification of mail matter, the registry and money order systems, and particularly the proper addressing of letters and the importance of placing return cards on envelopes. Postmasters should arrange, if possible, to deliver personal talks to the pupils on these subjects and should give teachers access to the Postal Guide and the Postal Laws and Regulations and render them every assistance in securing necessary information.

G. v. L. Meyer,
Postmaster-General.

SCIENCE TEACHING IN SCHOOLS.

By Arthur S. Dewing,

Harvard University.

A study in the relation of science teaching to the general problems of education.

(*Concluded.*)

IV. Science Teaching and Induction.

The basis of the laboratory method is the first-hand reference to facts. These facts alone are mere isolated and senseless fragments which assume any real value or significance only when some kind of life is infused into them. The facts must be interpreted. The pupil must move from the single to the general, from the fragment to the whole. This is scientific induction and is quite different from scientific observations. There is one and only one principle—the student must be made to do all his thinking for himself. The whole purpose of the observations is to acquaint the student with facts from which he may reason, and if the free play of his own reasoning is interfered with in any way the whole purpose is thwarted. It is much easier and more rapid for the teacher to do a large share of the reasoning for his pupils, but such an attitude defeats its own ends. The attitude on the part of the pupil is the thing of vital importance. He may look upon the laboratory work as a drudgery in which he tries to prove or disprove the facts that his teacher has taught him. This is too frequently the case. It springs from an altogether wrong order of work in which the pupil is first lectured to or otherwise instructed and then goes through the motions of the experiment in the laboratory. Common as this order is it undermines entirely the spirit of the laboratory method. The pupil goes into the laboratory with the facts that he is expected to observe distinctly fixed in his mind and worse than that, his teacher has told him just what conclusions he ought to draw. Personal initiative is entirely thwarted. The pupil learns to regard his laboratory work as a set of superfluous tasks, a series of things to be done in as short an order as possible. Owing to the fact that he has been told beforehand the observations which he should make and the conclusions which he should draw he comes to look upon his part as purely perfunctory.

Words of condemnation for this kind of teaching can hardly be couched in too strong terms. Its only excuse is that it is

much easier for the teacher and pupil, because it requires far less effort on the part of either. The teacher can prepare a lecture on the Voltaic cell or on hydrogen without much mental exertion, and the pupils, after having learned the properties of the cell or of hydrogen can then go to the laboratory and find out that the things they have already learned seem to be true. It is the shortest way to teach an array of facts under the semblance of using the laboratory method. One single experiment in specific gravity, one single study of a starfish might be of far greater value than a long list of experiments hastily performed or a study of twenty or thirty animal forms. It is quality and not quantity that we want in education, and this high quality is reached only when each and every pupil has been required to personally reflect on the facts that his laboratory work has brought to light. The function of the teacher in the laboratory is that of guide. He should assist only when every effort to make the pupil work out his own conclusions alone fails. It is the mental effort of close and consecutive thinking that counts educationally. If this is true then a single experiment might conceivably have greater merit than a whole series. If the pupil knows next to nothing of the results of his experiment, as he enters the laboratory, then the whole experiment can be used as a form of mental discipline. The pupil should be told exactly what to do, as far as the mechanical technique is concerned, and he should then be made to pass from the fact to principle without relying on anything else than his own reason. Few external results may blossom forth, but the far subtler power of mental grasp has been enhanced. The pupil has learned the better how to think for himself.

If the student is made to think out the conclusions alone there is also gained an understanding of the sharp distinction between fact and theory, which is of inestimable advantage to the right comprehension of the science itself. According to the lecture or text-book system, fact and theory, observation and hypothesis, are hopelessly intermingled. In this confusion a student soon learns that facts, and the conclusions which have been drawn from them, are on the same plane, a bit of information which he must unlearn sooner or later—the sooner the better. It is often amusing to notice the glibness with which a young student runs off chemical or physical formulæ. The first day he enters the laboratory he probably learns from his progressive teacher that the formula of water is H_2O. The

long line of intricate and distinctly theoretical reasoning upon which this formula is based is as unknown to him as the remotest star. When questioned a few weeks later he might tell you that the formula, H_2O, meant that water consisted of two parts of hydrogen and one part of oxygen. He has never heard of the laws of definite proportions, and the combination of gases by volume, of the atomic theory and of Avogadro's hypothesis and the laws of the expansion of gases; and yet the formula of water has greater assurance to him than it has to most chemists. One is often convinced that if a high school teacher of chemistry can make his students understand why the formula of water is H_2O or that of sulphuric acid is H_2SO_4 he has done all that can possibly be required of him in a single year of work. The insight of a teacher is often indicated by the point at which he introduces formulæ. The later he can postpone any reference whatever to them the greater is his teaching ability. If he can make his pupils feel the real want of formulæ, then make them reason out their form through all the intricate theory and hypothesis upon which they depend, he has done all that could possibly be asked of him—and more than many college teachers have done. Contrast the educational value encompassed in the mere memory act of learning that water is called by Mr. Jones and Mr. Smith by the expression H_2O and the long train of reasoning necessary for the student to understand, and perhaps reason out himself, the series of observations and experiments, of theories and hypotheses, upon which this simple shorthand expression depends! The latter is a longer and more arduous road, but how much more worth while! If teachers would only realize that the community does not expect them to make scientists out of their pupils, but it does expect them to teach their pupils how to observe and how to think for themselves, how to correlate results and to see things in proper perspective.

This suggests a word about certain current notions—that science teaching should be made as interesting and as little arduous as possible. Let us omit mathematics from physics because students do not get so much enjoyment—and therefore benefit—out of quantitative work and problems as they do from playing with apparatus. Make science teaching as pleasant and attractive as one can and the ideals of education are realized, a "primrose path,"' a royal road to learning. A course of

physics consists in watching "the twentieth century limited" and chemistry in a visit to a soap bubble factory. The whole spirit of this movement is wrong, its influence on education is enervating, even vicious. We have learned through long experience that the valuable fruits of educational endeavor are dearly bought, that the undefinable and subtle thing we call mental power is purchased only through long continued and diligent effort, effort which must summon moral fibre, steadfastness of ethical purpose to its aid. Men are not trained by making their training as agreeable and entertaining as possible. Our schools are not kindergartens. Science teaching has a definite and difficult problem before it and its mission is not furthered by listening to every educational fad that clouds the horizon.

Aside from the theoretical grounds, the efforts to make science teaching easier by smoothing away the hard places fails in its practical results. Consider for example the suggestion of omitting mathematics from physics. Physics possesses a wonderful advantage over such sciences as geology or botany in that a pupil may be taught in terms of certain theoretical principles, principles which he himself may discover in the laboratory; he may then apply these principles to concrete phenomena. Mathematics is the language of universal quantitative values. The theoretical laws of physics have the great advantages of being in such a form as to be capable of expression in this language. A problem in physics, therefore, becomes nothing but the application of this universal means of expression to practical examples. A pupil cannot really comprehend a theoretical principle without being able to apply its universal language to particular cases. No pupil can understand the significance of Boyle's law until he has done a number of problems dealing with the pressure and volume of gases, until he has applied the universal language of the expression of the law to particular cases.

The laboratory method, considered then in the aspects of a means of observation and of induction must represent the broadest effort on the part of teacher and pupil to arouse individual action. It is the basis of any method of teaching science where mental training, rather than fact learning, is the ideal. The success of science teaching in meeting the demands of education rests on its ability to train minds, to develop mental power, along just those lines which we have characterized as scientific thinking—and to do this is the spirit of the laboratory method.

THE SIPHON AS A QUANTITATIVE LABORATORY EXPERIMENT.

By H. W. Harmon,

Grove City, Pa.

In reading Professor Fisk's note on the siphon in the January, 1908, number of School Science and Mathematics the thought came to me that most of us are missing a good quantitative experiment on the laws of liquid flow, and a chance to drive home again the laws of falling bodies and the principles of acceleration. The siphon is about the only practical experiment on liquid motion that we have, and yet out of all the many Physics Manuals in general use, it is found in only two or three.

The facts concerning a siphon, some, at least, of which it may seem desirable to test are:

1. The amount of flow is directly proportional to the time.
2. The rate of flow is directly proportional to the square of the diameter of the tubes, or to the cross sectional area.
3. The rate of flow is directly proportional to the square root of the difference in length of the arms or "head."
4. The rate of flow is independent of the density of the liquid.
5. The velocity of the liquid flowing through the tube is constant and is equal to that of a freely falling body, falling from a height equal to the "head."
6. The efficiency is less than 100% due to the viscosity and eddy currents in the tube and at the mouth of the siphon.
7. The efficiency is higher in large tubes than in small.
8. The efficiency can be increased by properly shaped orifices.
9. The rate of flow (neglecting friction), is independent of the total length of the arms, but friction exists and the efficiency is lower as the total length is greater.
10. The steady flow velocity is not instantaneously attained.
11. The siphon in action possesses kinetic energy, which can be used to do work (c. e. in the hydraulic ram).

Let us analyze the forces that produce the flow in a siphon: In Fig. 1:

Let W_s = the weight of the water in the short arm
" W_l = " " " " " " " long arm
" M = the total mass of water in the siphon
" $W_h = W_l - W_s$ = the "Head"

" P_a = pressure of the air upon the water in A
" P'_a = " " " " " " " " B

The altitude of A and B being practically the same

$$P_a = P'_a \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

It is evident

$$W_s < W_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

W_s opposes P_a and W_1 opposes P'_a. Subtracting 2 from 1,

$$P_a - W_s > P'_a - W_1 \quad \ldots\ldots\ldots\ldots 3$$

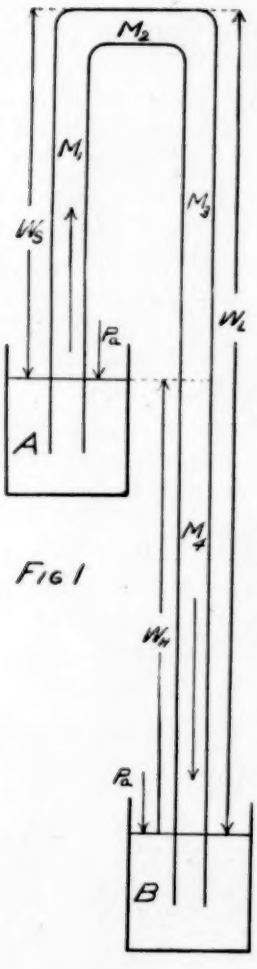


FIG 1

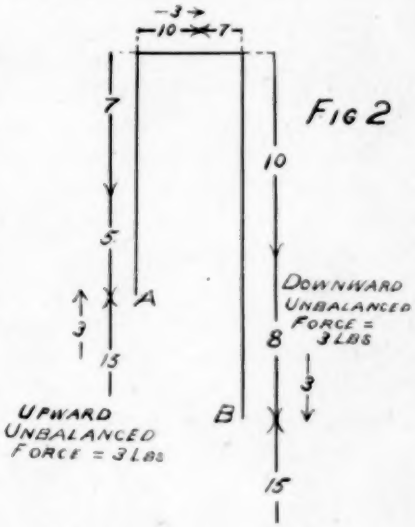


FIG 2

FIG 3

The direction of flow will be from A toward B, for, when directly opposing forces act on a body, motion takes place in the direction of the action of the greater force. In this case the body acted upon is the entire quantity of water that is in the siphon tube, and the unbalanced force is equal to the difference between the weights of the two columns of water,

$$W_l - W_s = W_h, \text{ (i. e., the Head of Water)}$$

To illustrate: Suppose the atmospheric pressure = 15 lbs. per square inch and the weight of water in the short arm of the siphon = 5 lbs. per square inch (= a column about 11.6 feet high) and the weight of the water in the long arm = 8 lbs. per square inch (= a column about 18.6 feet high) and that the weight of the water in the horizontal column = 2 lbs. (= about 4.6 feet). To diagram the forces acting at the surface of the water in A and B inside of the tubes and on the water in the horizontal part of the siphon:

The pressure of the air at A and B, Fig. 2, subjects the water in the tube to compression. The pressure of the air at A has 10 lbs. of its value unneutralized by W_s. This unbalanced force is transmitted around through the water of the tube (Pascal's Principle) and is added to W_l at B making a total of 10+8=18 lbs. downward force at B. Likewise the atmospheric pressure at B has 7 lbs. of its force unneutralized by W_l which is transmitted around through the water and is added to W_s at A, making a total pressure of 7+5=12 lbs. downward pressure at A. The forces acting on the horizontal water column are the unbalanced transmitted forces 10 lbs. and 7 lbs. which are in opposite directions and which if paired leaves a resultant of 3 lbs. in the direction of B. It is thus seen that the pressure at A is not the difference between A_p and W_s nor the pressure at B = $A_p' - W_l$ as was pointed out by Professor Fisk. This unbalanced force of 3 lbs. is equal to the "head" $(W_l - W_s) = (8 - 5)$ lbs.

An unbalanced force acting on a body produces acceleration.

$$F = Ma \quad \ldots\ldots 4$$

Where F is in poundals or dynes

Then $$F = W_h = M_h g \quad \ldots\ldots 5$$

Combining 4 and 5

$$M_h g = Ma \quad \ldots\ldots 6$$

then $$\frac{a}{g} = \frac{M_h}{M} \quad \ldots\ldots 7$$

or $$a = \frac{M_h g}{M} \quad \ldots\ldots 8$$

That is, the water in the siphon to start with will have an acceleration compared with a freely falling body, in the same ratio as the mass of the head of water is to the total mass of water in the siphon.

This acceleration occurs only at the beginning of flow and is but momentary, lasting only until steady flow is established, which is when the unbalanced pressure W_h, is forcing its maximum volume of liquid into the mouth of the siphon. Thereafter the liquid in all parts of the siphon is moving at this constant velocity. This velocity, if there were no friction at the mouth of the siphon or along the inner surface of the tube, would equal that of a freely falling body falling from a height equal to the head (Torricelli's Theorem).

$$V = \sqrt{2gh} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 9$$

The rushing of the water particles in A, Fig. 1, from all directions toward the orifice crowd each other and produces "eddy friction," which wastes the energy and reduces the effective pressure and consequently reduces the velocity of flow and efficiency of the siphon.

It will be of interest to experimentally determine the amount of these losses.

From 9 it is seen that the velocity of flow should be directly proportional to the square root of the "head" and not as the first power of the "head."

Further, it is easy to see that the total volume of flow will be directly proportional to the total time of flow; and also to the cross sectional area or to the square of the diameter of the tube.

If all bodies fall with equal velocities, a dense liquid should flow through a siphon no faster than a light one.

Anything that will reduce the crowding of the water particles around the orifice, such as increasing the diameter of the short arm or using a funnel shaped orifice will increase the flow and efficiency.

A series of trials involving these factors can be made and the data plotted as curves, bring out very clearly the effect of each factor.

The apparatus shown in Fig. 4 consists of a reservoir tube (7x125 cm.) kept filled with water to a constant level (determined by the overflow tube) from the faucet. The siphon tube is held in position by the clamp which slides up or down the vertical rod as needed. These are mounted on a board 15x150 cm.

The siphon tubes used are four in number, each with equal parallel arms 10 cm. apart and 110 cm. long. The diameters of Nos. one, two and four being about .5 cm. 1.0 and 1.5 cm, respectively, giving relative cross sections of 1:4:9.

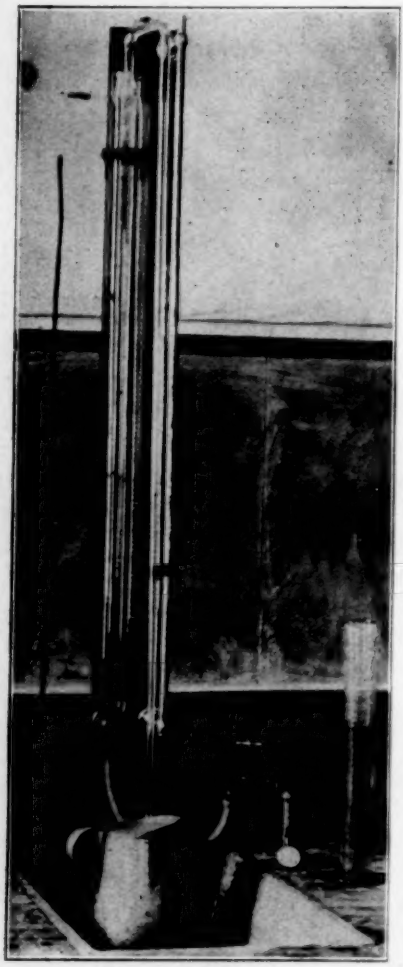


FIG. 4.

The third tube is a compound one of the same length of arms but having diameters of about 1 cm. and 2 cm., the larger one was drawn down and sealed into the smaller one at the bend (see Fig. 3).

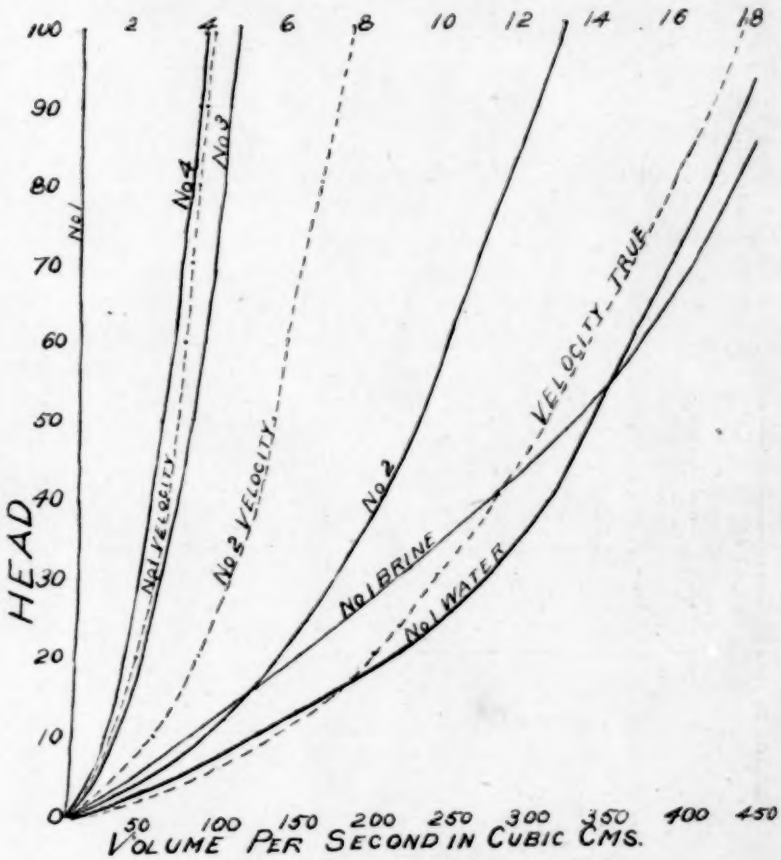
The "runs" are timed with a stop watch, caught in gallon or half gallon cups, and the amount of water caught, measured in a liter graduate. The stream lines around the orifice can be nicely studied by watching any suspended particles or air bubbles, introduced if necessary by a filter pump attached to the faucet.

The curves are seen to be parabolas and not straight lines.

The difference in curvature, in curves Nos. two, three, four and one indicate the effect of diameter on the volume of flow.

Curve No. 1, water, which is the same data as No. 1 but plotted on a larger scale (25:1) brings out its curvature and when compared with No. 1 brine, plotted to the same scale, brings out the effect of difference in viscosity of the two liquids. While in tube 4 of larger diameter, in which viscosity is a smaller factor, the brine curve and water curve when plotted were almost exactly identical (data not given), showing that the volume of flow is independent of density.

The curve No. 3 of the compound tube though of slightly less diameter than tube No. 4, yet shows a greater volume of flow; thus showing the effect of increased efficiency due to larger orifice.



Further the velocity curve of No. 1 and No. 2 compared shows the velocity of flow for the smaller tube to be only about one half of that of the larger tube and the velocity of No. 2 less than one half the true velocity, which is the same for all of the tubes. This shows strikingly the effect of friction in tubes of small bore.

The volume of flow from the wide arm of the compound tube is almost exactly the same as that from the small arm, showing that the smallest diameter of a siphon largely determines its discharge rate.

In the practical working of this experiment the brine runs

SMALL TUBE NO. 1	DIAMETER = D_1 = .48 cm. CROSS SECTION = A_1 = .182 cm².									LARGE TUBE NO. 2	DIAM. = D_2 = 1.46 cm. CROSS SEC. = A_2 = 1.69 cm².					
Trial No.	Arms L−S = Head H	Time of Run in Secs = T	Total Volume of Flow = Q_1	Flow per Sec. = q_1	Velocity of Discharge = $q_1 \div A_1 = V_1$	Comput'd Velocity = $\sqrt{2gH}$ = V	Efficiency = $V_1 \div V = E_1$	BRINE Total Volume = Q_B	BRINE Flow per Second = q_B	Head H	Time T	Total Volume = Q_2	Flow per Sec. = q_2	Velocity of Discharge = $q_2 \div A_2 = V_2$	Efficiency = $V_2 \div V = E_2$
1	10 cm	60	295 cm³	4.9 cm³	26.8 cm	141 cm	19. %	195 cm³	3 25 cm³	10 cm	10 sec	925 cm³	92.5 cm³	58.2 cm	41.2 %
2	20 "	"	520 "	8.7 "	47.8 "	200 "	23.8 "	370 "	6 17 "	20 "	"	1400 "	140. "	88. "	43.8 "
3	30 "	"	660 "	11. "	60 7 "	243 "	24.9 "	530 "	8.8 "	30 "	"	1750 "	175. "	109.5 "	44.8 "
4	40 "	"	762 "	12.7 "	69.5 "	282 "	24.7 "	675 "	11.25 "	40 "	"	2070 "	207. "	129.5 "	45.7 "
5	50 "	"	825 "	13.75 "	75. "	315 "	23.8 "	805 "	13.4 "	50 "	"	2320 "	232. "	137. "	43.2 "
6	60 "	"	885 "	14 8 "	81.2 "	345 "	23.5 "	905 "	15.1 "	60 "	"	2500 "	250. "	147.5 "	42.7 "
7	70 "	"	950 "	15.8 "	86.5 "	372 "	23.3 "	985 "	16.4 "	70 "	"	2700 "	270. "	159. "	42.7 "
8	80 "	"	1018 "	16.95 "	92.7 "	398 "	23.3 "	1055 "	17.6 "	80 "	"	2900 "	290. "	171. "	42.8 "
9	90 "	"	1067 "	17.8 "	97.6 "	428 "	23.2 "	1110 "	18.5 "	90 "	"	3100 "	310. "	183. "	43.1 "
10	100 "	"	1135 "	18.9 "	102. "	445 "	22.8 "	1155 "	19.25 "	100 "	"	3275 "	328. "	193.5 "	43.3 "
1	10 "	20	690 "	34.5 "	57.5 "	Efficiency A's	40.7 "	A_3, H_2O Large Arm		10 "	30 "	825 "	27.5 "	39.3 "	27.8 "
2	20 "	"	1000 "	50. "	83.3 "	8.2 %	41.6 "	1080 cm³	54.0 "	20 "	"	1200 "	40. "	57.1 "	28.5 "
3	30 "	"	1246 "	62.3 "	103.8 "	8.25 "	42.4 "	1350 "	67.5 "	30 "	"	1450 "	48.3 "	69. "	28.4 "
4	40 "	"	1508 "	75.4 "	125.7 "	8.55 "	43.3 "	1560 "	78.5 "	40 "	"	1700 "	56.6 "	80.1 "	28.4 "
5	50 "	"	1703 "	85.1 "	141.8 "	8.7 "	44.8 "	1760 "	88. "	50 "	"	2000 "	66 6 "	95.1 "	30.2 "
6	60 "	"	1860 "	93. "	155. "	8.7 "	44.8 "	2030 "	101.5 "	60 "	"	2225 "	74 2 "	106. "	30.6 "
7	70 "	"	2000 "	100. "	166.7 "	8 5 "	44.75 "	2130 "	106.5 "	70 "	"	2400 "	80.0 "	114 3 "	30.7 "
8	80 "	"	2150 "	107.5 "	179.1 "	8.25 "	44 75 "	2200 "	110. "	80 "	"	2625 "	87.5 "	125. "	31.2 "
9	90 "	"	2250 "	112.5 "	187.5 "	8.35 "	44.5 "	2360 "	118. "	90 "	"	2800 "	93.3 "	133. "	31.5 "
10	100 "	"	2375 "	119. "	198.3 "	8.5 "	44.4 "	2550 "	127.5 "	100 "	"	2950 "	98.3 "	140.4 "	32.3 "

COMPOUND TUBE NO. 3	DIAMETER D_3 = .87, D'_3 = 2.07 cm. CROSS SECTION A_3 = .60, A'_3 = 3.33 cm².	MED. SIZED TUBE NO. 4	DIAMETER D_4 = .94 CROSS SEC. = A_4 = .70 cm².

have proved time consumers, due to the necessity of often returning the brine runs to the supply reservoir and also to the brine becoming smeary about the table. So the brine runs have been taken carefully and this data is given to the student to complete his own data table.

The experiment, though a little long to complete in one laboratory period (the experiment is credited for two), I find three good students working well together will usually complete it in a period of three hours.

It is an experiment that the students get interested in. It has "the go" about it. The catches have to be accurately timed (one student should make the whole series of ten trials for a given tube to avoid personal error). The student that measures has to keep ahead of the "catches" and the third student records on all three data sheets. Finding efficiencies is what catches their interest. I find it the same with other experiments: the efficiency of the pulleys, wheel and axle, inclined plane, jackscrew, etc.; these are the things they want to know; they generally already know the law. They also like to find out how large their errors are in other experiments and will often work overtime to eliminate them, if there seems any chance to do so. An experiment should bring to light some new fact to the student's mind. If experiments do this, there will be no trouble in making laboratory work interesting.

This siphon experiment is proving to be a practical, interesting, and instructive experiment and if tried will find, I believe, a regular place on our experiment list.

AN IMPROVED FORM OF PROJECTION OBJECTIVE

By E. J. Rendtorff,

Lake Forest Academy, Lake Forest, Ill.

When the lantern is used for the projection of apparatus the inversion of the image is extremely annoying and undesirable. It is just as rational to project inverted images of slides and consider that good practice.

The regular method for reërecting the image is by means of a 90° prism, mounted with its hypotenuse parallel to the optical bench, and placed directly in front of the objective. There are two great objections to this plan; first, the loss of illumination

due to the comparatively small aperture of the prism and the divergence of the rays from the objective: and 2nd, the separate adjustment of the prism for every different position of the objective on the optical bench, necessitated by the focusing of apparatus of different dimensions. This loss of intensity and time must be overcome to meet ideal conditions. The second objection can be obviated by attaching the prism directly to the objective, but in this case another objective of different magnifying power cannot be employed unless the mountings are of the same size. The prism is also too exposed to dust.

It is always desirable to use a lantern in a room not entirely darkened, so that the instructor can adjust his apparatus without difficulty, and incidentally tend to the discipline of his class, should it be necessary. The first objection to the standard method of mounting the inversion prism is therefore the most serious.

The ideal mounting is to have the erecting prism in the draw tube itself, between the lenses of the objective, as illustrated in Fig. 1. With the proper condensing lens a maximum amount of light will then pass through the objective and the illumination will be much greater than when the erecting prism is placed in

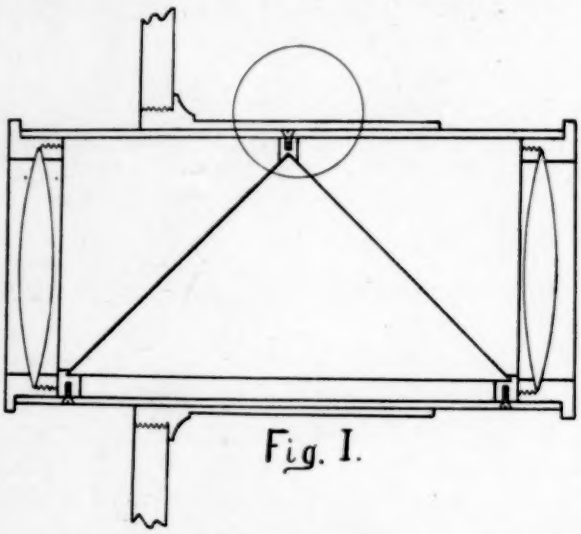


Fig. I.

front. The objective could be constructed so that the prism could be withdrawn from it, for the projection of slides, but I have found this entirely unnecessary except in large halls where the image is some twenty feet square. Where a lantern is used

for slide, or apparatus, and opaque projection alternately, it is even desirable to diminish the intensity of the directly projected image, so as to avoid a great contrast of illumination.

In vertical projection, where the image must be reflected from a vertical to a horizontal direction, either a plane mirror, or a 90° prism, used as a totally reflecting prism, can be employed. The latter is the better method for definition. The common method of mounting the prism directly above the objective is satisfactory, except that it is too exposed to dust. By slightly rotating it about a horizonal axis the image can be cast either high or low on the screen.

By mounting the prism between the lenses of the objective, as illustrated in Fig. 2, it can be made more dustproof, but no other advantage is gained thereby, except that the vertical height of the lantern is reduced and that the image now comes from a point closer to the direct projection objective than when the reflecting mirror is employed.

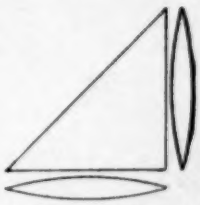


Fig. II.

It is frequently desirable to alter the size of the image, to show some part in greater detail. This is generally done by the use of various objectives of different powers, but their interchange is slow and the objectives costly. There are on the market several objectives of variable power, but they are too expensive for general use.

A method that I have found very satisfactory is to have four lenses, of different focal lengths, furnished with the ordinary objective. Each lens is mounted in a separate cell that can be held in the draw tube through friction, instead of the ordinary screw thread method, thus making the interchange of lenses in the objective very convenient and rapid. With these four lenses twelve distinctive magnifications are possible. An objective with the removable erecting prism in the draw tube, and a series of four interchangeable lenses, constitutes a system that would meet the demands of every occasion.

An erecting prism with a base of 2½ inches and faces ground accurate to four or five wave lengths of sodium light can be imported duty free for about $5.00 (Philip Harris & Co.) Higher grade prisms can be obtained, but the cheaper ones are very satisfactory. A prism with a larger angle than 90° would be more efficient, but these cannot be purchased on the open market.

POSITIONS OF REFERENCE.

By F. C. Van Dyck,

Rutgers College.

In order to assign definite values to the distances moved by bodies, or to their velocities, it is necessary to assume positions from which the distances are measured, and with reference to which the velocities are stated. The grounds for choice of the position of reference when kinetic energy of mass-motion is produced are set forth under the heading "Frame of Reference," in Jean's Theoretical Mechanics, from which I quote: "Thus we see that, in the theorem that the increase in kinetic energy is equal to the work done, it is legitimate to calculate both the kinetic energy and the work done by considering motion relative to the center of gravity only; i. e. the system may be treated as though its center of gravity remained at rest" (page 232). For example, let a projectile be shot from a freely supported gun. If the ratio of their masses is not very large the velocity of each is separately stated with reference to a point fixed relatively to their common center, and the kinetic energy of each is estimated with reference to a body fixed relatively to that center. If the mass of the projectile is relatively very small, some point on the gun may be taken as position of reference because the center of the gun would then remain nearly coincident with the common center of the system, gun projectile.

When work is done against friction causing heat directly, or indirectly by producing eddies in a fluid, mass *ratios* are of no importance. Even the *products* of masses count only so far as *weights* affect the frictions. I borrow an illustration from Crew's General Physics, page 79.

"If now the train be running *uniformly* at the rate of 24 miles an hour, we conclude that these opposing forces are exactly equal and opposite to the pull of the engine; and hence that the total force acting upon the train is zero. If steam be cut off the engine, the opposing forces accelerate the motion of the train in such a way as to diminish its speed. When the train comes to rest, the opposing forces become zero; and hence the total forces are again zero and the acceleration is again zero. When the engineer lets on steam the forward pull of the engine is greater than the backward pull of the opposing frictional forces. Hence the motion of the train is accelerated, this time in such a way that

its speed is increased. This acceleration will continue until the frictional forces are exactly equal and opposite to the pull of the engine. At this point the acceleration is again zero." It is plain that the force of the engine merely balances the resistances so long as it is exactly equal to them, doing no work on the *train* which moves in accordance with the first law of motion at a speed imparted by an accelerating force. Also the position of reference may be assumed at either end of a distance selected for computation of work done while rate of motion is uniform.

The process of lifting results in production of energy of configuration. When a man lifts a stone the first step is to exert, for a brief interval of time, a force slightly in excess of the weight of the stone in order to give it an upward velocity. Then the lifting force is diminished until it is exactly equal to the stone's weight. So long as this equality is maintained the lifting force merely does work against gravity, stretching the lines of force linking the stone to the earth as one stretches the spring of a balance by pulling on the ring and hook. The lifting force proper does no work on either earth or stone. When the stone has reached the desired height the lifting force is made less than the stone's weight until gravity has brought the stone to rest. The *product,* not the *ratio,* of the masses of stone and earth counts in lifting. The stone rises, while the lifting force is equal to its weight, exactly as it would rise if both lifting force and weight were suppressed. So far as computation of work is concerned we may measure the distance from plane of earth to plane of stone, or vice versa, without regard to disparity of masses, since energy of mass-motion is left out of account.

Thus far only work-equations have to be considered, but equations of moments must also be stated when work is done by means of levers. In any instance of leverage the agent's force is applied, directly or through a rigid connection, in each of two parallel planes (perpendicular to the line of motion), and the derived force which balances the forces of the system is also applied in each of a pair of parallel planes. Usually the axis of moments is taken in that plane which is common to the two pairs. For instance, when a man standing on the earth lifts a stone by a lever he is *directly* connected to the earth through his feet and his force is applied directly to earth and to lever, while the derived force (equal to weight of stone) is applied to the lever and also through it to the earth. Hence the plane of the earth, being

common to both forces, is the plane of reference for both work-equation and equation of moments, and the axis of moments is where the lever turns upon the earth or some support rigidly connected to the earth. When a man uses his foot as a lever to lift himself the force of the calf-muscle is applied in each of two horizontal planes, passing through heel and ankle-joint respectively. The planes in which the lifting force is applied pass horizontally through ankle joint and junction of toe with earth. so the common plane of reference for the work-equation passes through the ankle-joint. It is generally admitted, even by those who maintain that the axis of moments is at the toe, that the work-equation of the foot is: force of calf-muscle $\times$ rise of heel relatively to ankle $=$ weight of man $\times$ rise of ankle relatively to toe. The "force at the toe produces no motion"; neither does the force at the ankle, for the relative motion of body and earth is due to an accelerative (not the lifting) force. To the lifting force is opposed the resultant force which links the center of the earth to the center of the body, and this mutual force comes equally from earth and from body, appearing as a downward pressure at the ankle and an upward pressure at junction of earth with toe. If, then, this mutual force may be regarded as the "load" or "weight," it is as truly "at" the toe as at the ankle, and it may be located as required for harmony between the work-equation and the equation of moments. Surely the present vogue of the doctrine of conservation of energy makes work-equations of prime importance.

MULTIPLICATION.

A. LATHAM BAKER, PH.D.,

Manual Training High School, Brooklyn.

In a recent number of the SCHOOL SCIENCE AND MATHEMATICS, p. 574, 1908, we find the sentence, "Such vagaries as 'multiplication is the process of performing upon one of two given numbers the same operation as may be performed upon unity to get the other, seem to have very little value."

It seems surprising that a definition so broadly applicable as the one given above should be called a vagary, especially as there is nothing to take its place. The beauty of this definition of multiplication lies in the fact that it covers the ground from arith-

metic (positive numbers) up through fractional, negative, complex to quaternion numbers (directed numbers); multiplication is the doing to the multiplicand (operand) what was done to unity to produce the multiplier (operator). And it applies to all these numbers without the change of a single word for new circumstances and larger fields. With it, when applied to quaternion number, creeps in the noncommutivity of factors, not as some new convention intrusively destructive of old conventions, but as a necessary result of the old conventions in their new field of action, revealing that the commutivity in the lower fields was a mere accident which gracefully bows itself out when it faces the portals of the larger quaternion life. Generalizing it, we have a still more widely applicable definition, which now applies to continuous as well as to discrete magnitude (vide Grassmann's *Ausdehnungslehre*): multiplication is the operating upon one magnitude guided by the properties of another magnitude.

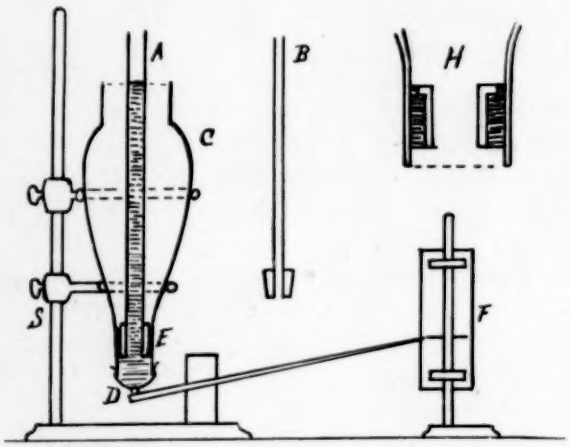
Another beauty of the definition in its application to discrete quantity is that a reversal of the property of the guiding quantity or at least a reversal of its aspect, that is, considering it convertible into unity instead of evolvable from unity, immediately gives us the definition of the inverse operation, division; the doing to the operand (dividend) what was done to the operator (divisor) to convert it into unity. The text-books generally beg the question when it comes to defining division, and speak of it as the inverse of multiplication, the finding a number which when multiplied by the divisor shall give the dividend. A definition should be positive and independent, not the leech-like parasite of some other definition. Nowhere can the critic of this definition find a substitute more comprehensive, more generally applicable, more logical in its application to reversed conditions. In fact where can he find any substitute whatever? All other definitions offered are partial in their application, useless and erroneous when extended beyond the narrow confines of the special branch in which they are found. But here is a definition which covers all phases of the subject. Under the circumstances, isn't it rather hypercritical to call it a vagary and useless?

INEXPENSIVE APPARATUS FOR ILLUSTRATING THE "HYDROSTATIC PARADOX."

By F. R. Gorton,

State Normal School, Ypsilanti, Mich.

The apparatus shown by Mr. Chas. H. Smith in the January (1908) number of School Science and Mathematics has suggested the simple method for illustrating the "hydrostatic paradox" with inexpensive materials, as described below:



In the small end of a large lamp chimney C is cemented with plaster of Paris or paraffine the neck of a bottle of suitable size to fit a large rubber stopper (see H in figure). Across the small end of the chimney is tied a piece of thin sheet rubber D. A small glass tube B and a larger one A are provided with rubber stoppers which fit well in the aperture H. The apparatus is mounted firmly on the ring stand S as shown in the cut.

In the manipulation, tube B is inserted in the inverted chimney and filled with water to the level of the open end of C. As the force exerted by the water against the rubber increases, the index rises. The final position of the index is marked by a heavy black line on the cardboard which slides on the vertical rod F. Now tube B is removed and the larger tube A inserted and filled to the same level. The index rises promptly to the height marked by the line on the card F. Finally tube A is removed and the chimney is filled to the brim. The index rises to the same point as before.

One of the chief merits of the device is the fact that no water has to be removed from the apparatus during the experiment.

COMPOSITION AND RESOLUTION OF FORCES.

By B. L. Steele,

Shortridge High School, Indianapolis, Ind.

The following is an experiment which I have been using with my classes for several years and, as it seems to me, with much better results than with any other experiment I have tried for this purpose. In our laboratory there is a wall shelf around the room supported on iron angle brackets, and hence I make this experiment the basis of the study of the composition and resolution of forces. It is found in substance in several manuals but as I have used it, it furnishes, I think, a less artificial treatment than does the conventional experiment. When my students have completed the study in connection with the experiment they feel that they have been working on a real problem and not on one which had been especially arranged for them, and one to be found only in the laboratory.

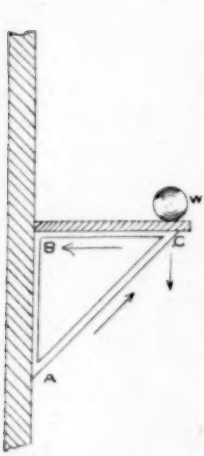


FIG 1

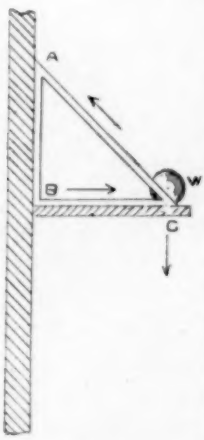


FIG 2

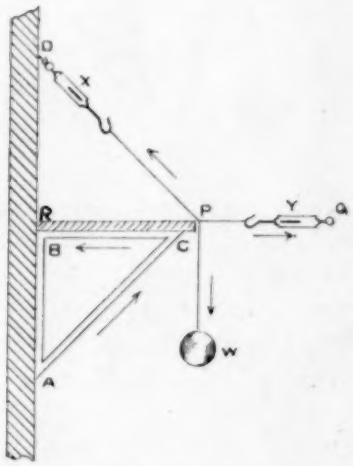


FIG 3

When several forces act at a point on a body at rest the forces are said to be in equilibrium if no motion results from the action of the forces. By the *resultant* of two forces is meant a single force which can produce the same effect as the two forces combined.

To each end of a short string attach a spring balance, pull on each so that a knot in the string will remain stationary and record the reading of each balance. Repeat several times, vary-

ing the strength of the pulls. How do the directions of the two compare? The magnitudes? What is each force called with respect to the other? What are the conditions of equilibrium of *two* forces acting at a point?

The brackets supporting the wall shelf present an interesting case of the equilibrium of *three* forces acting at a point. When an object rests on the edge of the shelf as at W in Fig. 1, its weight acts vertically downward. To prevent its moving the angle iron AC pushes and CB pulls as shown in the figure. Fig. 2 shows another possible arrangement of the bracket which would support the shelf equally well but in which the forces would act as indicated, however, in no way essentially different from those in Fig. 1.

If an apparatus is arranged as illustrated in Fig. 3, the relation of the forces acting in Fig. 2 may be determined. W acts vertically, Y is adjusted so as to act horizontally by keeping the string in line with top of shelf. The direction of X is obtained by measuring PR and RO when Y is properly adjusted and P is just free from the edge of the shelf. The two balances should be read just at the time when this adjustment is made. The weight of W, if not known, should be determined by weighing with the spring balances. Since X holds Y and W in equilibrium, or is their equilibrant, what must be the direction of their resultant? What must be its magnitude?

Why may a force be represented by a vector? Make a vector diagram to some convenient scale to represent the magnitudes, directions and common point of application of the three forces X, Y and W. From the end of the W vector draw a vector to represent to the same scale the force Y. From the common point of application of the forces to the end of this vector draw a vector and determine its magnitude. How do its direction and magnitude compare with the direction and magnitude of the X vector? What is the force represented by this vector? State a method for finding the resultant and therefore also the equilibrant of two forces acting at a point. It is to be observed, therefore, that the condition of the equilibrium of three forces acting at a point is that when a vector diagram of the forces is made, taking the forces in any order, the vectors form a triangle.

Conversely, if the direction and magnitude of a force are known, could not this method be used to find the magnitudes of two forces acting in given directions which would hold it in equilibrium? Show how. If, then, the greatest probable weight

to be placed on the wall shelf is known, could not the constructing engineer determine the magnitudes of the two forces AC and CB, Fig. 1, in the bracket? Then, knowing the strength of the material, could he not determine the size of iron out of which to make the members of the bracket? This method of determining the magnitudes and directions of resultant and in other cases component forces is very widely used, for example, in preparing specifications for roof and bridge trusses.

DEPARTMENT OF CHEMISTRY ENGLEWOOD HIGH SCHOOL, CHICAGO.

By Albert L. Smith.

In the fall of 1888 when the first part of the present building, the north wing, was opened Professor Fernando Sanford had three rooms placed at his disposal for the use of the chemistry and physics classes.

The "Science Room" at the west end of the building had regular class room seats and was used for recitations and demonstrations by both chemistry and physics classes. This room was provided with two alcoves, which could be closed off from the main room by double sliding doors. The rear alcove contained cases and shelves and was used for storing apparatus; the front alcove contained a sink and small elevator, connecting with the chemical laboratory below.

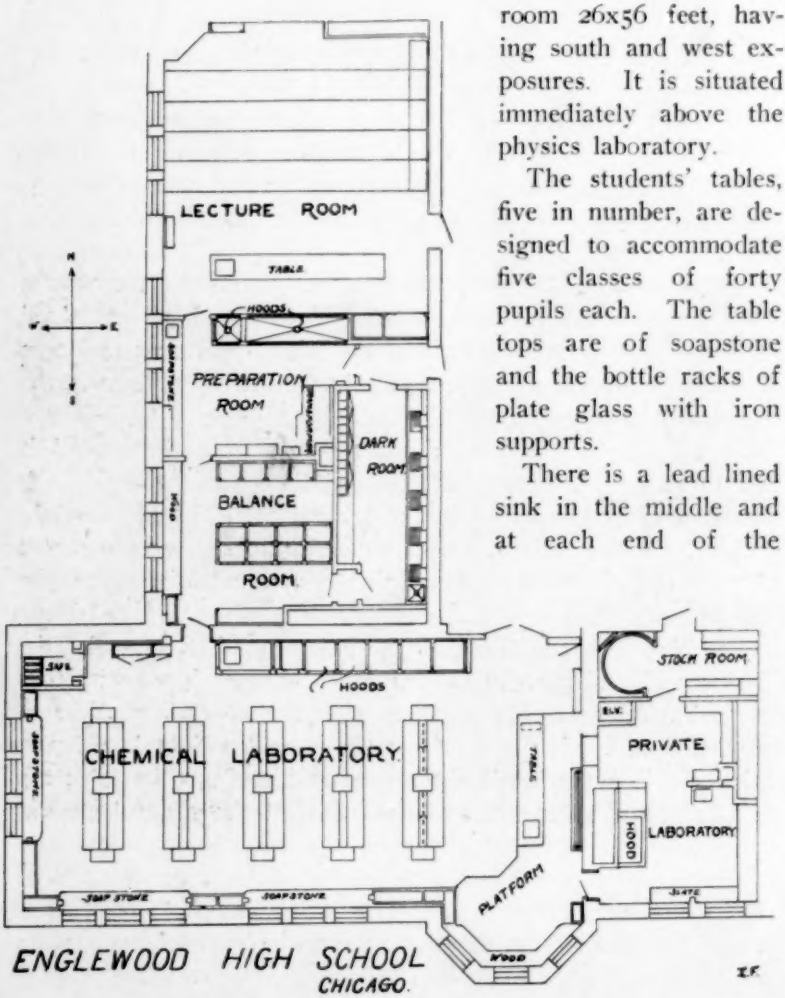
Some years before the "Science Room" was demolished it had to be used for other classes and the chemistry work was almost entirely conducted in the laboratory. The physics laboratory, the only one of the three rooms to survive the recent building operations, is now occupied as a commercial geography laboratory.

The chemical laboratory, in the basement, directly under the "Science Room" contained seven tables, each equipped with four large drawers on a side, cast iron sink at each end, gas, like all good things, coming down from above, and a tight board partition dividing the bottle shelves, extending from the table top to a height of about five and one half feet above the floor.

The large galvanized iron air ducts passing through this badly lighted room were a constant menace to the heads and habits of its occupants. In spite of its imperfections this laboratory, which was one of the first if not the first chemical laboratory equipped for high school pupils' use in this city, continued in

constant service until October, 1905, at which time it was vacated for the wreckers to do their part in preparing for the much needed "new laboratory." The move at this time was to the old mechanical drawing room, another basement room, here were taken the tables deprived of their sinks and bottle racks and for more than two years this room had to serve all purposes of the chemistry classes.

In February, 1908, the new quarters on the third floor were first occupied. These consist of the general laboratory, lecture room, etc., as shown in the accompanying plan and a store room in the basement.



The laboratory is a room 26x56 feet, having south and west exposures. It is situated immediately above the physics laboratory.

The students' tables, five in number, are designed to accommodate five classes of forty pupils each. The table tops are of soapstone and the bottle racks of plate glass with iron supports.

There is a lead lined sink in the middle and at each end of the

tables. These are connected by lead lined troughs which receive waste water from the two faucets available for each pupil.

There are two gas outlets and a downdraft hood, Altaffer's form, at each place. Under the middle sink, on each side of the table is a cupboard in which waste jars are kept. Two narrow cupboards on each side of a table, and a small drawer above it are for iron stands, test tube racks, etc., used by all classes in common. Each pupil is furnished a drawer, divided into convenient compartments for his own use.

At the three wall tables gas, compressed air and electrical outlets are provided. Cases for chemicals and apparatus are located at various places along the walls, while most of the north wall is occupied by a row of seven small hoods, each provided with gas, and the larger one with a deep sink and hot and cold water.

The northwest corner of the laboratory contains a vault with combination door. The keyboard and notebook cases are placed near the main entrance, while the bay is occupied by a wall table and two book cases.

The instructor's table at the east end of the room is equipped with sink, hot and cold water, air, gas, bottle rack, switch board and down draft hood. Back of this table are sliding blackboards, and shelves.

Adjoining the laboratory on the east is the instructor's private laboratory supplied with the usual conveniences for work. From it a dumb waiter connects with the physics and biological departments and the store rooms in the basement.

From the little stock room a spiral stair, back of the elevator just mentioned, connects with the same departments and basement storerooms.

The lecture room, designed to accommodate fifty persons at one time, is provided with raised seats, instructor's table, apparatus cases, sliding blackboards, etc. The table is equipped with hot and cold water, gas, compressed air, switch board and glass shelves for reagent bottles. The table top is of soapstone.

The sliding blackboards raise giving access to a large hood the bottom of which is a shallow lead lined sink. This hood has gas, water and sewer connections, and like all other hoods of the department is ventilated by the special fan in the attic.

This hood connects with the preparation room by raising the large panel sash forming its south wall. The preparation room contains soapstone wall table, sink, shelves and small apparatus case, besides the transformer. This machine converts the sixty cycle alternating current into 110 volt direct, four to eight volt direct, single phase and three phase currents for use in the chemistry and physics departments.

The dark room is provided with a long lead lined sink and movable racks on which to rest trays, fixing boxes, etc. The sink has faucets for hot and cold water conveniently placed, also one for distilled water. Above this sink are five developing lanterns fitted with ruby and yellow glass. In one corner of the room is a drying cupboard connected with a ventilating flue.

Between the preparation room and the general laboratory is the balance room containing twelve cases for balances, each having glass front and sides, electric light and two small drawers beneath. This room also contains two small apparatus cases, and cupboards beneath the windows.

Distilled water for the laboratories is provided by a Jewell still in the attic.

A NEW ALLOY.

A new alloy which has been brought out in France and is known as "Invar," has the valuable property of having practically no expansion, and is thus adapted for various purposes. M. Guillaume succeeded in forming such an alloy in connection with the Commentry-Decazeville metallurgical firm. Nickel steel is the base of the alloy, and up to 20 per cent of nickel, the expansion is about the ordinary. It then increases up to a value of 24 per cent, reaching a minimum value at 36 per cent of nickel, then rising and taking the normal value for a 50 per cent alloy. It is the 36 per cent metal which has the curious properties brought out by M. Guillaume, and its expansion is almost zero, being 17 times less than that of steel and about the same as for melted quartz. The new steel is not magnetic and it does not rust. Owing to these properties, it is already used at Paris and elsewhere in the construction of spiral springs, pendulums, graduated scales for instruments. Its field of usefulness is extensive, and it can receive many applications where these properties are needed. One valuable application is in the formation of standard measures such as the meter, and different standard scales have been made at Paris by the International Bureau of Weights and Measures. Such scales or gages are remarkably exact, owing to the non-expansion of the metal. They are used in the artillery works at present, and very precise work can be carried out with the gages and calibers, diminishing the errors which were found previous to their use. According to the tests made upon standard scales, these hold their value within a remarkably small percentage. By varying the amount of nickel in the combination, a second alloy can be formed which is valuable as having the same coefficient of expansion as glass, and it can thus be used to replace platinum in the leading-in wires of an incandescent lamp, thus reducing the cost of these wires to a comparatively low figure. It can also be used to replace the platinum wires of eudiometers and Geissler tubes for the same reason.—*Scientific American Supplement.*

THE HIGH SCHOOL MUSEUM.

By W. W. Robbins,

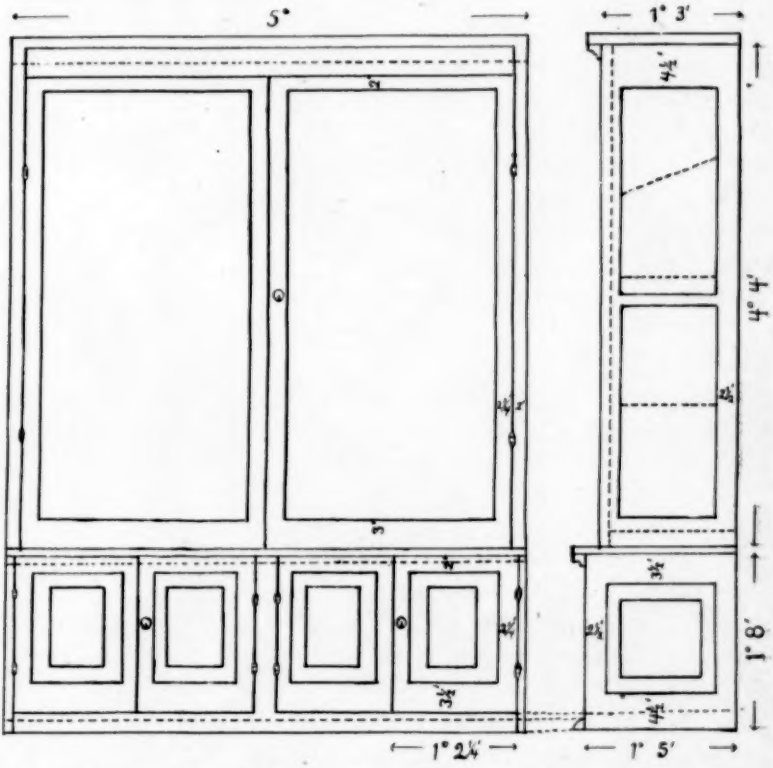
University of Colorado, Boulder, Colo.

Comparatively few high schools in this country have their own school museums. It is true that high schools, especially in the larger cities, have their "collections," but too often they are so poorly arranged and maintained that their purposes are defeated and they fall short of being as important factors in the school work as they can be.

In many cases the lack of a school museum is due to a belief on the part of school authorities that they involve too great an expenditure of money. They are considered to be a luxury, something of no particular use, but very nice to have. The word "museum" is often associated with the thought of expensive cases filled with rare "curiosities" from distant parts of the world. It is true such a museum would be expensive, but it is also true that it would be as worthless as expensive. If there is anything for which a museum has no use it is a mere "curiosity." The high school museum need not be expensive either as to starting or maintaining. It should contain usable and instructive specimens which are chiefly representative of things of interest in the locality and which are collected and prepared, in almost all instances, by the students themselves. A museum of this kind will prove to be a valuable adjunct to the school work.

The following diagrams show the plans for a cheap and attractive case which has been tried and found satisfactory for museum purposes. It can be constructed of hard pine at a cost of about $35. The staining and finishing can be made to match the woodwork of the building. The doors and ends of the case are of glass. The shelves are adjustable, three or four conveniently going into one case. The upper shelf should slant downward so as to admit of better display. If the cases stand in a well lighted place, the shelves may be stained the same color as the outside of the case, but if the light is poor, the shelves and especially the back of the case should be painted white. The base of the case may be furnished with drawers or shelves, the latter being much cheaper. All the doors should be provided with locks. This case has an advantage over the show-case style in that it has no horizontal glass surfaces which are liable to be broken by leaning upon them.

Museum cases should be placed in the school halls, where the specimens are constantly seen by the students as they pass back and forth. In the halls the specimens will be examined much more often than if they are placed off in some basement or garret or room that is used for class work part of the time. It is highly important that the cases be in as conspicuous and accessible place as possible.



As previously mentioned, the material composing a high school museum can be and preferably should be from the locality in which the school is situated. The specimens should illustrate the geology, botany and zoölogy of the region. Science teachers will find more interest taken in field trips, as well as more profit derived therefrom, if collecting for the school museum is a part of that work.

Many high schools have a number of museum specimens, but they are often stored in boxes or closed, wooden-front cases where they are seldom seen, in many instances even by the teacher. Valuable specimens are often scattered about the rooms, piled in

the corners, in windows, on and under tables. Students should not be expected to look at such material. Museum specimens of this kind would have their value to the students increased ten-fold if they were arranged in glass cases, labeled, and placed in a conspicuous place. The formality in itself would command attention and stimulate an interest.

An equipment of museum cases and specimens is of course prerequisite to a good museum, but the value of a museum to a school depends, for the most part, upon the manner in which the specimens are displayed and the use made of them for instruction. The proper grouping of specimens is very essential. A Pleistocene skull should not be exhibited alongside of a bluebird's nest. A museum is not a miscellaneous lot of objects brought together with no purpose; it should consist of carefully chosen specimens which are arranged for some purpose. Museum specimens should not be merely to look at but should be illustrations of facts or exponents of ideas. Each case or portion of case should be confined to the illustration of some one fact or one group of related facts.

Labels should be attached to everything. They should be clear and distinct, and should convey as much information as possible in an accurate, concise, and readable form. They should be written with typewriter (record ribbon) or with waterproof India ink.

The writer has found the "Riker Specimen Mounts" exceedingly valuable for the preparation and display of specimens in an attractive and instructive form. These mounts may be obtained from the American Entomological Co., 1040 DeKalb Ave., Brooklyn, N. Y., from Kny-Scheerer Co., Nos. 225-233 Fourth Ave., New York City, and probably from other laboratory supply houses. The mounts are provided with a glass cover; the specimens are arranged on a cotton background and held in place by pressure of the glass front. They are made in various sizes, but those of the dimensions 6½x8½ inches, 8x12 inches, and 12x16 inches are found to be the most useful. Their cost is reasonable. Although primarily intended for entomological collections, they are adaptable to a great variety of things, such as plants and plant parts, shells, bird's eggs, and geological specimens. They are particularly useful in that they admit of the grouping, under glass cover in one frame, of specimens that are to be related in the mind of the student. It is a decided advantage from an edu-

cational standpoint to have the student see things in relation and comparison to each other.

In order to illustrate specifically some of the uses that can be made of the Riker mounts and at the same time give some idea of what can be done to start a museum with material from the immediate neighborhood to draw upon, an example will be discussed somewhat in detail. Suppose the subject to be "Leaf Venation." The student could be asked to collect, as a part of his botany work, a set of leaves showing various types of venation and to arrange them tastefully in a Riker mount. At the top of the mount would be the subject "Leaf Venation"; each leaf would be neatly labeled, telling the kind of venation and the name of the tree from which it came. The name of the student who made the collection, arranged and labeled it, should be attached to the mount. Such work by the students does not fail to arouse interest and lead them to a better understanding of their subject. In addition to their museum purposes, the mounts can be used year after year in the class work. They are in a convenient and instructive form and can be handed around a class without danger of destroying the specimens.

There is almost an unlimited number of things that can be arranged in the above manner, and by assigning to each student a different subject, a respectable and valuable museum will soon be had. The following is a list of only a few suggestive possibilities, suitable for display in Riker mounts: various leaf shapes. plant organs, compound leaves, types of leaf surfaces, twigs and bud arrangement, seedlings, parasitic plants, fruits showing adaptation to dispersal, characteristic Alpine plants, shade plants, plants from rocky soil, types of flowers, autumn coloration in leaves, snails, insects showing mimicry, butterflies, life histories, fossils from certain horizons. Other things will be placed side by side in one mount for purposes of comparison. A few suggestions in this line are: leaves from same plant showing variation, sun and shade leaves of the same species, air and water leaves from same plant, simple and compound leaves, staminate and pistiliate catkins. Immediately there occur to the reader many more subjects which would admit of the same treatment. Individual and smaller mounts will hold shells, fossils, birds' eggs, etc.

All of the above mentioned specimens can be exhibited in ways other than in Riker mounts, but not so attractively and in such a

permanent form, admitting of such admirable grouping and arranging of objects.

The local geology offers a rich supply of valuable museum material. Different kinds of wood, cut in longitudinal, tangential and radial sections, could be shown; to these might be added commercial specimens from the lumber yard. It would cost very little to arrange exhibits of cereals, nuts, spices and condiments, quarry products, different kinds of bark, commercial starches, weed seeds, oil seeds, varieties of petroleum, by-products of petroleum, varieties of fibers, different kinds of leather, and some of the more common medicinal plants. There can be collections of birds' nests, of reptiles and fishes, to be preserved in museum jars. Some students will take an interest in mounting the skeletons of the common small animals. It is not unusual to find some high school student who is able to do the simpler kinds of taxidermic work. The museum will afford an incentive to the students to take up such work. Recently acquired pieces of physical apparatus, either from the dealer or made by the students, and the more interesting chemicals can be placed in the cases for a short time. Labels should accompany them, indicating their uses.

It is a good plan to change the specimens in the cases quite often. Students tire of seeing the same objects day after day, and hence soon become disinterested in the museum work as a whole. But if new specimens are placed on exhibition at frequent intervals the students' interests in the work are kept alive. Furthermore, the enthusiasm for and success of the work will largely depend upon the part the students themselves play in the building up of the museum. There is no end to the number of valuable things of interest the students will bring in, when they know there is a proper and definite place for them, and when they realize that the specimens go to the upbuilding of a school interest and are really made use of by the school. When the museum has become well established due to the work of teachers and students, the patrons and townspeople will be found to take an interest and make worthy donations.

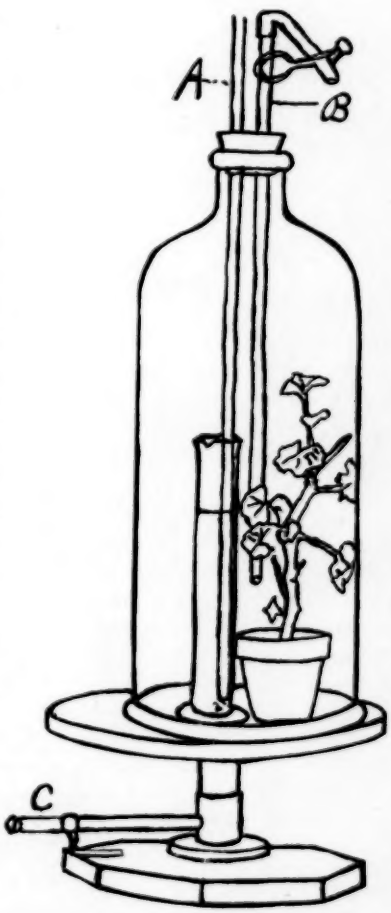
The museum has been discussed with the high school particularly in mind, but the suggestions, with some modifications, are applicable to the grade schools as well. Every grade school, as well as high school, should have its museum, a few cases where the collections made by the students may be kept in a permanent and instructive form.

A SIMPLE PLANT EXPERIMENT.

By E. S. Gould,

Galva, Ill.

The following device for showing the necessity of CO_2 in photosynthesis may be of use to teachers of botany, especially where apparatus is limited.



A bell glass with a rubber stopper is placed on an ordinary pump plate. The tube C of the plate is closed with a cork. In the cylinder inside is placed NaOH or $Ca(OH)_2$ to absorb the CO_2. Air is forced through tube A (tube B being open) for a few minutes until the most of the air in the bell glass is devoid of CO_2. What CO_2 is left in the glass will be absorbed by the NaOH in the cylinder. The air is changed every day so that if there were anything in air beside CO_2 that helped in photosynthesis the plant would be sure to have it. Tube B is kept closed except when it seems necessary to introduce water through it to the plant. Before commencing the experiment the leaves of the plant were found to contain starch, but after continuing it three days all traces of starch disappeared, thus proving that CO_2 is necessary in photosynthesis.

The department editor wishes to raise four questions relative to this experiment:

1. Do the pupils know enough chemistry to enable them to prove that NaOH or $Ca(OH)_2$ takes CO_2 from the air?

2. Is it true that forcing the air through the liquid in the cylinder by means of tube *a*, and out of the bell jar through tube *b* "for a few minutes" would render "most of the air in the bell jar" devoid of CO_2?

3. How does the pupil know that in watering the plant through tube *b* you do not introduce CO_2 sufficient for the plant's uses?

4. Does this prove "that CO_2 is necessary in photosynthesis"?

Do not all the points raised in these question refer to things that the student must take for granted upon the authority of the teacher? If so, would it be quite as well for the pupil to assume in the beginning that the teacher is correct when he says that CO_2 is necessary to the process of photosynthesis?

O. W. C.

In general, the amorphous graphite is the more impure, and is used for purposes where purity is not a prime requisite. Thus graphitic schist mined in Georgia is ground and put into phosphates used for fertilizer, as a black color is demanded by consumers under the supposition that it means better quality. In Michigan graphitic rock is ground for use in paint. Such materials are of course cheaply prepared and are unfit for the better uses, such as in crucibles, lubricants, and electrical work.

To the Editor of School Science and Mathematics:

Please allow me this brief reply to "Some Comments on a Communication," page 752, Vol. 8, No. 9, 1908.

Though the parallel postulate cannot be verified, yet within the limited space of human experience it holds good practically; if the opposite postulate leads to no beneficial mechanical constructions or fruitful scientific hypotheses, why is it not a justifiable use of language to say it has no *real* or objective meaning?

In regard to the value of geometry as a study "to cultivate the powers of reasoning" when applied to non-geometrical material, a good test has occurred to me. Suppose the expert geometers who voted at the late election should look into their own hearts fearlessly, and question how far their vote was influenced by habits of thought due to their geometrical training; and then publish the result of their self searching in School Science and Mathematics—that is, frankly state whether they honestly believe their vote would have been different, if, retaining their present economic and social status and mental furnishings otherwise unchanged, they possessed no more geometry than their friend "the banker, lawyer, Indian chief." Would not that be an extraordinarily interesting test?

Lucy Beales Upham.

Boston, Nov. 24, 1908.

SOME REMARKS ABOUT THE METEOROLOGY TO BE TAUGHT IN A HIGH SCHOOL COURSE IN PHYSIOGRAPHY.*

By Mark Jefferson,

Department of Geography, State Normal College, Ypsilanti, Mich.

Meteorology is usually there in the book, usually late in the book. This is said to be because "The Land" must be attacked in the fall so as to make ilustrative excursions. I wonder if it is not also so as to get it out of the way? I wonder if it does not at times happen that the meteorological part of the subject is omitted altogether? Of the authors of recent physiographies only one so far as I know has made any published studies in meteorology. He is almost alone in putting it first in his book.

I am aware of the general belief that in meteorology, as in psychology, it is not necessary to study before you can teach, though I believe meteorology differs from psychology in that it is regarded as less proper to write on the subject without having studied it.

Thus it happens that some writers of text-books of physical geography and very many teachers of the subject teach that hot air rises and that snow clad mountains often bring about rainfall by cooling moist winds that blow upon them from the ocean.

Now I think that pretext that the atmosphere is put off to get at the earth by out of door excursions in the fall is all moonshine. In the first place what is being done by way of excursions in most high schools seems to me quite insufficient to raise physiography to the rank of an observational study. Of course that depends on what one calls adequate excursion work. For myself I should want several years of weekly excursions to properly illustrate the amount of matter in our usual texts. I find all laboratory or excursion work to be very slow in one sense of the word. It is hard to get over very much ground. In the sense of mastery I believe it is almost the only way to get any at all. But it does take time to really do and visit and measure and test, instead of merely reading. I have a class in field geography in spring and fall and you will see what I think of the right amount of excursions when I tell you our class period is from two o'clock till dark four afternoons a week, and two thirds or more of our exercises are held out of doors.

*Read before the Earth Science section of the Central Association of Science and Mathematics Teachers, November 27, 1908.

One of the great gains that was proposed in 1893 by the Committee of Ten, which you may say licensed and called for the present physiographic instruction, was to introduce observation into geography: p. 211, "to develop the power and habit of geographic observation," and the committee enlarged on that object considerably. Physiography is not really being taught as an observational study, for I do not believe average teachers make even one excursion a week with their students. Perhaps the teachers here present do, but over against them must be set many others who never attend educational gatherings to which they are not driven. The subject that we have in the schools is largely a book subject.

The difficulty under present conditions of making it anything else gives me an inclining toward meteorology. In my own state I know by investigation that the practical difficulties in the way of field excursions mostly result in preventing them. I know that there are earnest teachers who surmount these difficulties, but I fear they are a minority. Real observational work with the weather has no such difficulties. One does need to make excursions to get at it. It is about the easiest aspect of nature to observe that there is. I wish more teachers had interest in it.

All that the Committee of Ten said in 1893 of the value of observational work is still true to-day, and I want to put it forward as the first point that I have to make this afternoon that the meteorological part of physiography lends itself more to practicable observational work in a high school than any other part of the subject.

Modern physiography views the earth-forms as a stage in a process, or perhaps a temporary balance between the two opposed processes of tectonic uplift and atmospheric denudation. Geology finds longish names like Plutonism and Diastrophism for the forces of uplift but concludes in the end it knows very little about their nature. Meteorology on the other hand has a good deal to tell us about the agents of denudation.

The most conspicuous of these agents is rainfall. It varies so widely from place to place in the world that we may say there are three distinct physiographies as a result—one of the lands of moderate rain like our own, the quite different one that Walther and Passarge are introducing to us for the desert, and that of the very humid lands which is so masked by vegetation that we have barely notes on it at present. Thus a fundamental physiographic fact is the distribution of rainfall.

To illustrate specific climatic control that might well be alleged for physiographic features there are the fiords on west-facing mountain shores in the zone of the westerly winds—on the Pacific in Alaska and Southern Chile, on the Atlantic in Scotland and Norway and the Southern Ocean in southwest New Zealand. If Africa has no equivalent part on the Atlantic it is because it does not reach far enough south to attain the zone of the westerlies. New Zealand has no northern mate since there is no Northern Ocean.

The loess offers another specific illustration of definite meteorologic associations. It too occurs in the path of westerly winds. Always to the west of it the desert as if it had blown from thence as dust. Itself always in the border region of increasing rain as if fixed by moisture or checked by the plant cover of a rainy region. Such are the two standard occurrences of the books, but the meteorologic associations are not mentioned either for the Mississippi Valley deposits or for those of China. The rather careless draughtsman who sketched the base map for many years in use by the United States Geologic Survey has put a fiord on the west coast of Mexico that could have hardly remained there these twenty-five years had the meteorologic relations of physiography been generally recognized.

The objection will be made to these suggestions of meteorologic interest that we care more for the moderately wet region as the home of most men and neither fiords or loess are of much physiographic importance. This brings me to my second point.

When values in education come to be clearer than at present it is not at all certain that physiography will remain the form of geography generally taught in the first year of the high school. For some of us, who regard geography as the study of the earth in relation to man, are inclined to test physiography as fit for early school use by its ability to make clearer this relation. Physiography the science will classify and treat all the features of the earth's surface regardless of their utilization by man or their capability of such utilization. I think such considerations do not belong to the science at all. But physiography in the first year of the high school is another matter. Here the parts of the subject that aid in perceiving the effect of man's environment on his activities have a preference over other parts, since the high school's business is to educate for life. There does not exist to-day an organized body of geographic applica-

tions of this sort to use, but as was the case with physiography fifteen years ago such material is rapidly gathering. Now it may well be more help will be had to this end from meteorology than from physiography, for it is climate rather than physiography that distinguishes the Sahara from Illinois for the uses of man.

That there is some account of life in all the current texts of physiography is due I think to pressure constantly exerted through the publishers by school men and notably elementary school men, for school men are unwilling to accept a geography that has no account of the reactions between life and its environment. The position of the Committee of Ten on this point was regarded as extreme and has met growing disregard. The committee distinctly discouraged any such account of what it called applications of geography. It wanted them relegated to works on botany and zoölogy. One of the earliest and best of the texts said in its preface that the author made many applications to organic life throughout the book but did not care to have a special chapter on life. Four years later a new edition of the same book appeared with a separate chapter on the distribution of plants, animals and man! All but one of the texts have now such a chapter. Am I fanciful in seeing something of an air of yielding to pressure, of adding something extraneous that they regard as not wholly germane in the authors' treatment of these chapters? The last text has this chapter written by other hands!

I repeat that the material extant for the rational study of man's reactions to his environment is not yet well organized. There are many fine studies, of which the best seems to me Huntington's Mountains of Turkestan.* There is, however, no doubt that success in making out human relations will demand a knowledge of climatic facts and meteorologic principles as almost its first equipment.

It is suggested therefore that the teachers of physiography of to-day who will give more and more attention to the atmosphere will find opportunity for observational study that the earth forms do not always allow, while such work will lead especially well to establishing those relations of earth and man that are the crown of the work so far as high schools are concerned.

*Geographical Journal, January and February, 1905.

ON THE DEFINITION OF AN ANGLE.

By G. A. Miller,

University of Illinois, Urbana, Ill.

In the December number of this journal Professor W. F. White raised three questions in regard to a certain definition of an angle. The term angle relates to one of those fundamental notions which are difficult to define in a satisfactory manner. In fact, such an eminent authority as *Traité de Géométrie* par Rouché et De Comberousse,[1] contains the following statements in regard to this term: "One expresses an idea which is clear to everyone when one says that two lines AB and AC which meet form an angle. This notion, like that of a straight line, is fundamental and cannot be defined; that is, it cannot be replaced by a more simple one."

On the other hand we meet with many so-called definitions which are regarded by scholars as mere tautologies. Among these it is customary to class the one given by Euclid, which affirms that an angle is the "inclination" of two intersecting lines[2]. Such definitions as, "An angle is the divergence of two intersecting lines" and "An angle is the difference in direction of two intersecting lines" seem to belong in the same category. It should, however, be observed that while these definitions may be tautologies for the trained logical mind, they may render real service to the beginner, as one of several equivalent terms may appear to express more than another.

As early as 1774 Louis Bertrand defined angle as an area in his "Dévelopments nouveau de la partie élémentaire des mathématiques." This definition has been very widely adopted and in the third edition of the well known German geometry by Henrici und Treutlein it is expressed in the following terms: "Two half lines from a point divide the plane into two parts; each of these parts is called an angle. The two half lines are called the legs of the angle and their common point is called its vertex. The boundary of the part of the plane between these half lines is arbitrary and is not taken into consideration. The angle is regarded as an open piece of the plane. We may regard an angle as generated by the rotation of a half line."

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[1] Fourth edition, 1879, p. 5.

[2] Cf. F. Enriques, Encyklopädie der Mathematischen Wissenschaften, vol. 3, p. 2[5]

The famous Italian geometer, F. Enriques of the University of Bologna, in the article to which we referred above remarks that the essence of the concept of an angle rests upon the existence of a certain invariant of two intersecting lines as regards the group of movements. The concept of such an invariant (the size of the angle) is sufficient for the ordinary theory of congruence. Another noted Italian geometer, G. Veronese of the University of Padova, has suggested that the angle might be defined as the totality of rays lying between two rays of a plane pencil. Such definitions, however, do not appear suitable for elementary instruction in geometry.

In some of our best geometries the term angle is defined as the figure formed by two straight lines drawn from a point. If such a figure is the angle we have to measure the figure when we measure the angle, as we do when we express its magnitude in degrees, minutes, and seconds. It is questionable whether the measure of such a figure, without further explanation, would convey any clear notion to the student. It is evident that it would be desirable that a definition of angle should be so formulated that it would appear at once natural to speak of the measure of an angle in terms of some unit of measure.

The objections raised in the preceding paragraphs are not meant as destructive criticism. Their main object is to emphasize the following statement: Probably every thoughtful teacher sees many pros and cons as regards some of the definitions which he uses and which he adopted after carefully considering these pros and cons, and after arriving at the conclusion that, on the whole, the definitions adopted are the most useful ones within his knowledge. A useful definition to which objections may easily be raised may be much more desirable than a practically useless one which is free from other objections.

As may be inferred from the preceding developments the writer of the present note does not pretend that the definition of an angle which he has adopted is free from all objections. Hence he would probably not have attempted even a partial answer to the questions raised by Professor White, in such a kind spirit, if it had not appeared that some general elementary considerations of the possible definitions of an angle might be of interest to many readers of this journal. The third question raised by Professor White relates to a matter of great general interest but its answer does not seem to affect the definition

under consideration since this definition is proposed for beginners, who would naturally confine themselves to Euclidean geometry.

The other two questions relate to slight modifications of the proposed definition and do not affect its essence. The first would not have been raised if it were generally admitted that, for the sake of convenience of expression, we shall say that a line is always parallel to itself. The second question applies to some of the other well known definitions. It is sometimes answered by giving direction to the lines and saying that the angle between two directed lines is the measure of the least rotation of the first line on one of its points so as to make the positive ends correspond when the lines become parallel. Whether it is desirable to be so explicit as to give direction to lines and angles in a first course may be questionable but greater clearness could certainly be attained in this way, and, as a rule, definiteness tends toward simplicity.

The definition under consideration is directly available to express the angle between two non-intersecting line segments lying in the same plane, for we may rotate one of these segments about any one of its points just as a line is rotated about one of its points. Just as it is convenient to speak of the angle between two non-intersecting lines in space so it is often desirable to speak of the angle between two non-intersecting line segments whether they lie in the same plane or are not coplanar. Moreover, this definition furnishes a natural interpretation of the convenient expression that the angle between two parallel directed lines is either 0 or π.

Although we cannot enumerate all the proposed elementary definitions of a plane angle, it may be of interest to add the essence of the one developed by Kurt Geissler in volume 12 of the *Jahresbericht der Deutschen Mathematiker Vereinigung*, since this definition is so closely related to the one under consideration. It is based upon a circle whose center is the vertex of the angle. In fact, the angle is defined as merely the number of degrees, minutes, etc., in the arc of the circle intercepted by the sides of the angle. This definition is made logically possible by establishing the congruence of triangles without making direct use of the angles.

FRACTIONS AND RATIO.

By George Bruce Halsted,

Greeley, Colo.

A fraction is one or more subunits of the kind identified by the denominator. Thus 2/3 is two units such that three of them make the primal unit.

The fraction a/b is the number which multiplied by b will produce a. Thus when by division we mean multiplication's inverse, the result or quotient of dividing a by b is identical with the fraction a/b. Again if a given sect contain the bth part of the primal standard exactly a times, we say its length is the fraction a/b.

On a given straight take a point O as origin and from it lay off the bth part of the standard a times. The point P so reached may be taken to picture the fraction a/b. Fractions abound in the oldest work on mathematics. We see that a fraction is a couple of natural numbers, integers. So the system of fractions, like the system of natural numbers, is discrete, discontinuous. Any two fractions are commensurable, and the ancients never had any numbers which were not all commensurable.

Meantime Pythagoras had discovered incommensurability, and in Euclid's fifth book we find that every two magnitudes of the same kind are to have a unique relation which he calls their ratio. What then is this ratio? How does he define it? Of course he does not define it; for if he had, we should have had a definition of irrational number, of continuous number, a strictly modern idea, even now in the crucible. Euclid proved that the ratio of two incommensurable magnitudes could not be represented by two numbers. We, to be sure, represent it by our new creation, the irrational, but would even we consciously think of our representative of the ratio of diagonal to side of a square, our new symbol $\sqrt{2}$ the square root of two, as a fraction, a number pair?

Says Professor Hedrick in the November School Science and Mathematics: "Do we know that there is a number whose square is precisely 2? Most assuredly we do not; in fact there is no integer whose square is 2, nor is the square of any fraction equal to 2, as will be seen upon inspection. What is this thing then? Is it a number, yet not an integer and not a fraction? * * * In fact the most careful definition of the 'square root of 2' is to define it to be the number which is approximated by the dec-

imals found in the process just described." So far is this from being "the most careful definition of the square root of 2," that in fact it suffers from several logical fallacies. The very article quoted tells us that the quantity to be approximated to must be itself defined. The process mentioned gives a set of increasing decimals with square always less than 2. A like process gives a set of decreasing decimals with square always greater than 2. The terms of the two sets approximate arbitrarily close to each other. But there is as yet no "thing" less than every term in one set and greater than every term in the other set. We may then choose to create such a thing, to set forth its rights to be called a number, and to give to it such freedoms, such restrictions, such laws for its multiplication that in accordance with them its square is 2. Here is no *petitio principii*, as in the so called "most careful definition." We create consciously an irrational number.

Euclid never took this step. For him no numbers existed but integers and fractions. He had not even decimals for the very good reason that no nought, no zero, no positional notation, no decimals existed. Ratios he had, but they were not numbers. He was past master of ratio. He proves the diagonal and side of a square incommensurable. But he compares, handles ratios never as numbers, fractions or even magnitudes, but by means of a concept more fundamental than the cardinal, more fundamental than quantity itself, the concept of order.

For him the ratio of x to y was the same as that of a to b if the interorder of the multiples of x and y was identical with that of a and b.

How deftly he applied his criterion to the sides of equiangular triangles, to rectangles and their bases, to angles and their intercepted arcs! Naturally of his demonstrations there were no incommensurable cases.

Measure had nothing to do with the matter. The ratio of the diagonal to the side of a square depended in no way upon their measures, nor upon use of any unit. He compared them by a device infinite in exactitude, the interorder of their multiples. Yet this presumes the assumption now named for Archimedes, and so at last in our own time the method of Euclid, admired throughout the centuries, has been superseded. We now have in English a geometry in which the word ratio never occurs. Much more should algebra drop it.

To retain the word ratio as a modern misnomer for its predecessor *fraction* is also a temptation to retain the burden of associated but obsolete nomenclature, "composition," "division," though this word has already two other meanings, remainder division and multiplication's inverse, "composition and division," "inversion," "alternation," etc.

An attempt to think of the ratio of two magnitudes is now an attempt to think of an irrational number, a concept so difficult that the best method of presenting it even to university students is not yet settled. The concept of ratio is still further disfranchised by its connection with the error, the blunder that number owes its origin to measurement, an error which wrought havoc among the lower grade teachers, though never countenanced by one single mathematician of repute.

To have dominated the continuum without the slightest use of measurement or ratio is looked upon as one of the greatest achievements of our time.

Let us then not confound fraction and ratio.

TUNGSTEN.

A reliable and constant supply of tungsten minerals is one of the most desirable conditions that could be brought about in this country. The demand is occasioned by the excellent purposes it serves in the manufacture of high-speed tool steel and of hardened steel for armor plate and heavy guns. In structural steel, for use in the modern steel buildings, bridges, etc., it is an important factor, because of its tendency to hold its temper when red hot, it being a common experience in cases of fire for steel to weaken and bend, working greater destruction to buildings. In the making of steel rails it is also of great value, as it is in steel projectiles and many other articles. While too extensive use may create brittleness in the steel, the introduction of nickel as a companion alloy has produced a superior product where great strength and temper are required in connection with malleability.

According to investigations conducted by the United States government, relative to the various steel hardening metals, report of which was issued in 1905, tungsten is contained in by far the greatest number of high-speed steels now in use. In using from 9% to 10.6% tungsten, the steel becomes very brittle, but at the same time the cutting efficiency is greatly increased and the use of about 16% appeared to be the limit, as no better results were obtained by increasing the tungsten beyond this amount. The use of from 1.8% to 2% of tungsten altered the steel considerably, making it softer, with the property of cutting very cleanly, but it was unable to retain its temper. It is estimated that from 5% to 8% of tungsten in the form of metal or ferro-alloy is sufficient to harden steel mixture for ordinary usage.

TWO PROJECTION DEMONSTRATIONS IN ELECTROSTATICS.

By Will C. Baker,

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1. The apparatus shown in Fig. 1 has been devised and successfully used by the writer in demonstrating that static electricity resides only on the outer surfaces of conductors, when they enclose no charge. A sheet of thin galvanized iron or tin plate, say 6 in. by 1½ in., is cut to the form shown at A in the figure. To this is hinged, as shown, the piece B, and to this again the piece C. On each side of A are two leaves of gilt paper (L, L) hinged to small eyes with fine wire. These are shown in deflected position in Fig. 1 and the detail of the hinge is given in Fig. 2. Gilt paper leaves are used as either gold or aluminum leaf is too much affected by the air currents due to the heat of the beam from the lantern. Gilt paper is sufficiently light to make a good indicator yet it is heavy enough to be unaffected by the air currents. If the hinges are carefully made there is no trouble with the leaves. The whole system is insulated from the stand by mounting on a block either of ebonite or of sealing wax. A silk thread (T) to the bottom of C completes the apparatus.

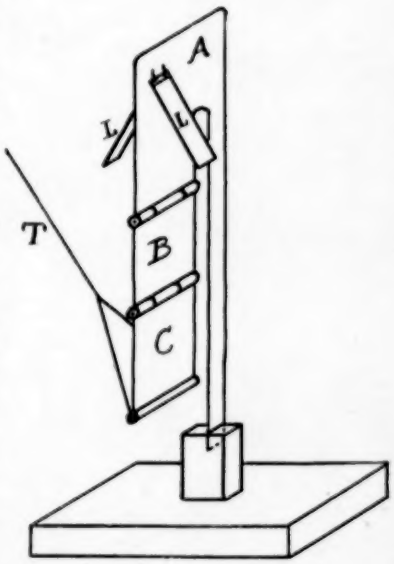


Fig. 1.

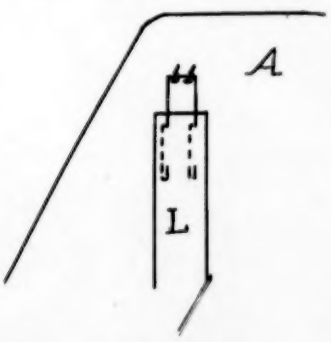


Fig. 2.

The demonstration is as follows: Placing the apparatus in the lantern with its plane at right angles to that of the condenser, one charges it from a rubbed ebonite or glass rod. The leaves are seen

to rise equally on the opposite sides of A. Now by pulling on the silk thread the hinged pieces are raised into the position shown in Fig. 3, enclosing one of the leaves, which immediately falls to its zero position, while the other leaf increases its deflection. On slackening the silk thread the hinged pieces fall into a vertical plane and the leaves return to their former positions. The hinged pieces may now be raised so as to enclose the other leaf with like results.

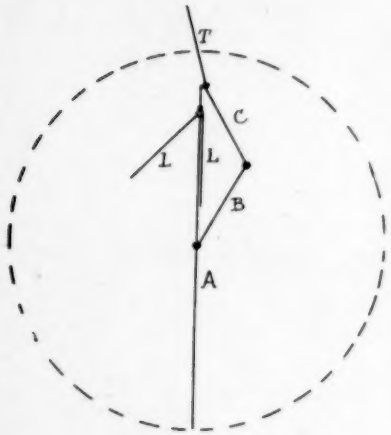


Fig. 3.

The behavior of the leaves thus makes it quite plain that the electricity always passes to the outer surface. The experiment is used to supplement the classic "butterfly net experiment" of Faraday and not as a substitute for it. Approximate dimensions may be obtained from Fig. 3 where the dotted circle indicates the area and position of the lantern condenser.

2. Modification of Mach's apparatus for showing the variation of surface density with change of curvature. Four pieces of thin metal are hinged together as shown in Fig. 4, the lower pieces hinging on part of the rectangular wire frame F. The hinge of the upper pair is extended so as to embrace the vertical sides of the frame, thus acting as a guide. The lower plates are cut away at the center, and two small gilt paper leaves (L, L) are hinged to the horizontal part

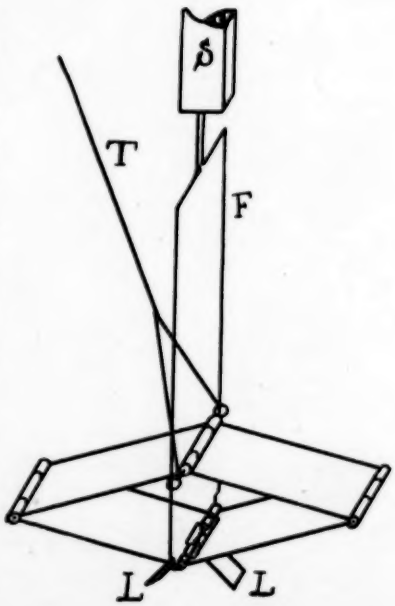


Fig. 4.

of the wire frame F, as shown in Figs. 4 and 5. This makes them perfectly free of the motions of the plates. F is insulated by a bit of sealing wax and a silk thread T to the guide rings of the upper hinge enables one to alter the angle of the lower plates at will.

If the apparatus be set in the lantern the hinged plates may be raised, by means of the thread so as to show first, that the movement of the plates causes no separation of the indicating leaves. After charging the system, however, the action of the leaves shows that there is a greater density of electricity at the lowest edge when the angle is acute than when it is obtuse. The axis of the leaves, it will be noted, is the point to which the attention of the class is especially directed, and with this design this is the point that remains stationary during the whole demonstration. This is of importance in the pedagogics of the design of demonstration apparatus. The idea and the essential features of the apparatus are of course Mach's, but the ease of operation and the effectiveness of the experiment are, it is thought, better in the form just described than in the older one.

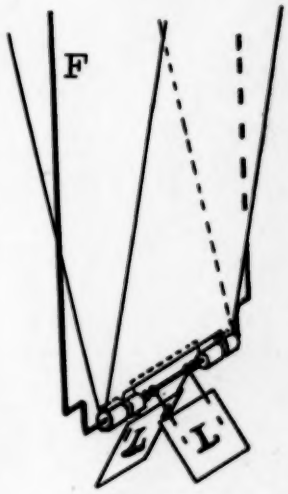


Fig. 5.

Note—In both of the above the silk thread must be quite clean and dry. It is often best to put on a new thread just before the class is to be met. In any case a bent pin stuck into the end of a bar of sealing wax will give a satisfactory insulating handle that will work in all weathers. The silk though is better, when possible, as it is finer and so does not look so clumsy on the projection screen.

A very strange and interesting fact in connection with the gold-bearing gravels in the Dawson district is that some are frozen even as far down as 250 ft., and some only to the depth reached by a single season of frost; and another strange fact is that in the frozen gravels the ice is free from detritus. The presence of ice to such great depths suggests a long period of very severe frost. The exact time of this severe frost it would be impossible to say, but it must have been previous to the formation of the creek deposits, which are not frozen. The absence of detritus in the ice, it is said, would suggest that the water was not in motion.

THE COURSE IN BOTANY.

By Otis W. Caldwell,
University of Chicago.

I. Present Conditions Relative to High School Botany.

In the June, 1908, number of the *Classical World* is a summary made upon data presented in the report of the United States Commissioner of Education. This summary shows that the sciences have declined in their popularity and use in the high schools, and granting the arithmetical accuracy of the summary, we at once ask ourselves, "What is the cause of this decline?"

To this question several answers and suggestions have been made. First, while the figures, as figures, are doubtless correct, they may misrepresent the actual situation. We must remember that at the beginning of this period certain subjects were fairly well established in the high school, others had just been introduced and others had not yet appeared. The number of classical, mathematical, and historical subjects that were in the high school at the beginning of this period was not enlarged within the period. In the sciences the number has been enlarged during this period, and the people interested in sciences at the beginning of the period have constantly had that interest spread over a larger number of subjects, thus giving a declining percentage to certain subjects, but not necessarily decreasing the whole number interested in science. For example, physiography has become one of the most successful high school sciences, and since the science requirements have not materially increased, nor the number of requirements in other subjects materially decreased, physiography may often have grown at the expense of other sciences.

Two other suggestions may be made toward explaining the statements in the report. One is that high schools are usually administered by people of classical rather than scientific training, for reasons we cannot enter upon; and another is that since there has been a large increase in the actual number of high school graduates who go to college there has been a corresponding increase in election in the high school of those subjects that are required for entrance in many colleges—namely the classical subjects. One may well say, however, that while the number of high school people who go to college has increased, so has the number who do not go to college, this fact rendering the latter explanation of questionable value.

We must face the fact that although several sciences have been introduced into the high school, they have not met with the marked success that was anticipated for them, and there are persons who claim that most of the sciences have not justified their existence in secondary schools.

II. What Is Secondary Education For?

To secure an adequate view of this situation we need to place clearly before us the function of the modern high school. When high schools first were established in this country they were designed solely as means of preparing young men to enter college. Their subjects were usually taught by ministers, and whether always openly recognized or not, a very potent purpose had to do with preparing young men to pursue theological studies. It should be said that at a very early date the purpose of these schools became more broad until they recognized their function as being to prepare boys for general college courses. Several things show, however, that this purpose was not ***unnecessarily*** broad, since each of these schools existed to prepare boys for meeting entrance requirements of some particular college. We still have many such fitting schools with such specific preparatory functions and many of them bear the names of the colleges to which they expect to send their students. Almost all colleges in this early day were compelled to maintain preparatory departments to fit students to carry college courses. The separate fitting school was sometimes directly stimulated and fostered by the college itself. As in the college preparatory schools attention was entirely confined to teaching those things required by the colleges for entrance, similarly in these fitting schools attention was and still is focused in the same direction.

As conditions of living and general ideals improved in the country, however, so that a total school period longer than that offered in the elementary schools began to seem desirable and possible to a considerable number of parents, the public high schools came into existence. It came into existence for two purposes: (1) As a means for extending more widely the preparation for college toward which fitting schools and private academies had been working, and (2) to give a better general education than was afforded in elementary schools without any reference to college. Probably the first regularly organized high

school was that organized in Boston in 1821. One at Portland, Me., was organized in the same year. The total number of free public high schools established in the twenty years between 1821 and 1840, in cities of 25,000 inhabitants and over, was seven.

The course of study in these schools was absolutely dominated by college entrance requirements. In this connection the statement made in 1903 by Supt. Seaver of Boston relative to the Boston Latin School is interesting. He says: "As in the beginning, so ever since down to the present time, this school has aimed to give the boys of Boston who wished to take it the best possible preparation for the university. Of course the 'University of Cambridge' was the only one thought of in the earlier years; but as other universities have arisen this school has opened the way to them all."

But in the earlier part of the second half of the last century two far-reaching questions arose. One was, "Should the colleges require a strictly classical course for entrance therein?" and second, "Should the high school exist primarily to prepare young people for college?" In response to arguments upon these questions numerous changes came into the high school curriculum. In some schools the entire course was changed, while in most of them special courses, as The English Course, The Scientific Course, and The Latin Course, were organized. The Boston English high school in at least one year prior to 1860 showed a remarkable attempt to meet the popular demand by announcing the following subjects in its curriculum: arithmetic, algebra, geometry, geography, general history, history of the United States, reading, grammar, declamation, rhetoric, composition, bookkeeping, natural philosophy, moral philosophy, evidences of Christianity, navigation, surveying, mensuration, astronomical calculations, constitution of the United States, drawing, logic, and French, all offered within the limits of a three years' course. This course speaks of recognition on the part of its framers of a need of making high school education worth more in practical living than previously had been true, but it also speaks of a great failure to see what really was involved in making high school education of most worth from the point of view of the needs of practical life. It speaks of an old and still living belief on the part of a good many people to the effect that a less thorough education is requisite for those who do not go to college than for those who do so.

We do not believe now that the high school's primary function is to prepare young people for college entrance. We do not believe that any less efficient education is needed for those who do not go to college than for those who do go. We believe, furthermore, that that education that is best for those who do not go to college is that which is best for all, therefore best for college entrance requirement. We believe that if the old purely classical education needed to be so largely supplemented by introduction to science, English, history of our own country, applied science, etc., in order to fit people to go directly into "practical life," very much more should these things be introduced for those who do not go directly into "practical life," in order that they, in their college courses, may maintain a proper perspective relative to the civilization in which they live. We need this to help maintain a proper balance in social sanity for those who by virtue of their future college work are in danger of losing that contact with practical living, which being lost, exposes them to the often well-based accusation that college graduates are less efficient members of society than their superior advantages justify us in expecting them to be. We need to plead for a *general* high school education quite as much for those who are to go to college as for those who are not to go. The colleges are recognizing this truer function of the high school, and at present some of them, and at an early date all of them must and will accept for entrance the graduates of all good four year high schools, almost regardless of what the four year course is. The high schools must be recognized as existing to give that general education which is best for the majority of its students. The college must be glad to help in finding what that "best" is, *but for the good of the pupils of the high school* holding subconsciously meanwhile the knowledge that what is best for the young people will prove best for the college.

It is not desirable that all or nearly all high school graduates should go to college, and we are beginning to adjust ourselves to this discovery. But it is best that the high school should present those subjects that, while giving best educative values, give fullest preparation for intelligent and sympathetic participation in the stage of civilization in which we find ourselves.

III. Some of the Functions of Botany in Secondary Education.

It would be pretty generally agreed, we shall assume, that high school education should give the best possible adjustment to the forces, activities, processes and materials with which young people must deal as they are becoming men and women of affairs. High school education should give people acquaintance with and an understanding of the kinds of things that must largely enter into their lives. Furthermore this acquaintance and understanding should be developed amongst materials that demand constantly new adjustments, since our whole lives are made up of changing relations to which we must always be making new adjustments.

What materials could be better suited to developing this attitude toward our surroundings than those of the sciences, and especially the biological sciences?

It is trite to say that our age is one of science and that to be intelligent citizens we must know the general facts of science. Trite as this statement is, we need to make it over again and again. We are in the situation of the minister who when accused by his deacons of preaching the same sermon regularly for three consecutive Sundays replied, "Certainly I have, but you have not yet done the things I urged in that sermon, why preach a new one?"

We sometimes fail to keep in mind that the new inventions and applications in practical life of modern science demand quite a different kind of training for intelligent living than did a former age.

"The applications of science to life have so transformed our surroundings that we live in a very different world from that of fifty years ago. To live properly in this new world is to understand it, to fit into it, and to make the best use of it. Since the changes are due chiefly to scientific inventions and improvements, progress in education calls for a direct and more practical acquaintance with sciences by common people."

"Every important invention or machine of applied science calls for a new expenditure of intelligence and foresight on the part of the many people who use it."—*C. A. McMurry.*

In a recent conversation with a man who is in charge of high grade machinery in one of the world's largest manufacturing

concerns, he said one great difficulty is that young men as they are growing do not grow into knowledge of machinery and when fully grown it is hard to teach them to earn what we can readily afford to pay for first-class service. We would not agree that a primary purpose of the high school is to fit people to run this man's machine, but the schools should give a larger general acquaintance with the general industrial life of which this large business is a part.

I suspect that much of the clamor for industrial, agricultural, and trade schools is due to the fact that our ordinary education is not educating for the kind of life that the most of the young people must live. Certain classical studies that once came logically from the lives of the people no longer find place in practical life, even in its broadest sense. But we retain these things, our colleges impose them upon high schools, and crowd to the wall those subjects that deal with the materials and processes that really make up the lives and daily work of the people. In commercial life, in industrial life and in agricultural life as a nation we have shown considerable ability to relinquish customs that are no longer organically connected with the life of the age. In education we seem unable to adjust ourselves, when it involves pruning dead branches, even if our best judgment tells us that the educational tree, through this pruning, would be more vigorous and more fruitful.

The strongest claim for continued use of some of these things is the discipline they are supposed to give. Concerning this two things need be said. First, a very considerable body of educational psychologists believe that formal discipline in one subject is not transferable to another field, it being useful only in the field in which it is learned. Secondly, securing proper discipline while doing something that is full of appreciable meaning is as much more valuable as securing discipline just for the sake of the discipline, as is exercise secured in playing a good game relative to that exercise one would secure in pitching sand back and forth over the fence. The discipline of botany and of other sciences enjoys the peculiar advantage of being developed in connection with materials that are to be encountered more or less in all life callings.

Botany offers material for proper stimulation of the problem solving attitude of mind, out of which should come a more accurate, more dependable, less wasteful method of thinking. The

experimental method constantly varying in its applications is the one to be encountered continually when out of school. In botany the life factor is always presenting new variations of the problems presented, thus affording opportunity for forming that plastic habit of mind which enables one to recognize the possibility of there being something in his field that he has not discovered. The true problem attitude of mind is one of humility and caution, but of active and intelligent investigation.

A working knowledge of cause and effect as developed in a biological science has much value. We are not all genuine believers in cause and effect, regardless of what our professions may be. In some unknown, unexplained way we often really expect that logical results of causes we have set working will not follow. We act as we believe that we may sow thistle seed and gather the fruit of figs. Careful and dignified work with plants should help to offset this all too common attitude of mind. We need remember, however, that this is a virtue which when definitely and openly sought will be much harder to secure than when secured as a by-product of good botanical teaching. The relations of plants to all sorts of practical life industries, agriculture, art, contact with out of doors—are often mentioned and need to be more fully recognized. Knowledge of plants and plant processes are necessary to the development of any of the leading functions of botany in education.

IV. The Principles that Should Determine the Course in Botany.

If there is a place for botany in secondary schools there certainly are principles upon which we may determine the general lines along which the course in botany should run. I should place as first of these principles that the materials selected for use in the course should have *appreciable significance* to the students. We have acted long enough upon the theory that it is a sign of weakness for school work to be full of practical meaning. It should be so, and loses thereby none of its educational values, but has them greatly increased. This appreciable significance may be found in a knowledge of practical use of materials, a general understanding of life problems, appreciation of the aesthetic aspects of plant life, desire for knowledge, or a knowledge of the basis of agriculture or other industrial pursuits.

Secondly, the materials must be of value for general knowledge by the public. There is a general culture value in knowing plant life, and the time has come when knowledge of the activities of plants and the part they perform in modern life is a part of the body of knowledge people must have in order to be properly intelligent as to their environment.

The materials of the course should be organized into a series of natural sequences to make possible the development of the problem solving attitude of mind, and to carry this series long enough really to give some facility and efficiency in thinking.

If the above principles are correct it follows, (*a*) that to develop appreciable significance the first work must be related to the students' previous experience in nature; (*b*) that as the course develops the problems of nutrition, reproduction, distribution, struggle for existence, agricultural and other economic features must be prominent, and that terminology must always be subordinated to proper understanding of processes and structures; (*c*) that none of the special aspects of morphology, taxonomy, ecology are to dominate, but plants are to be studied from any of these points of view as best suits the needs of the course; (*d*) that to develop the desired attitude of mind, the work must be based upon first hand experience with plants, and this experience and the work based upon it must be carried through a sufficiently long period of time really to make possible the development of the scientific way of looking at things. This involves not only sufficient time, but a logical relation between different parts of the course. This does not mean that all or most of the study of plants shall be first hand contact, but that enough contact must be had to make reading mean something.

V. Outline of the Course.

In presenting the outline of the plan for the course that I have worked out as based upon the foregoing considerations, due to time limits, I must at this time necessarily give but the general plan. I have divided the course into twenty sections.

Section 1. "Plants in nature," consists of a general discussion by teacher and pupils, which is designed to give initial point of view, intelligent interest and investigative attitude of mind. The topics considered are:

1. Universality of plants in regions at all favorable to their growth.
2. Relative number of prosperous plants in deserts and extremely cold regions.
3. Plants upon trees, rocks, and in caves.
4. Dependency of man upon plants.
   a. Food for himself, cereals, vegetables, fruits, sugar, etc.
   b. Food for his domesticated animals.
   c. Materials for clothing.
   d. Materials for building his home.
   e. Materials for his medicines, spices, beverages, etc.
   f. Paper pulp, ink, dyes.
   g. Coal in relation to plants of bygone ages.
   h. Covering of the earth.
5. Plants not primarily to serve man.
   a. They produce timber, fruits, etc., primarily for their own uses.
   b. Plants must work in order to live.
   c. Plants must have structures and materials with which to work.

It must be kept in mind that this section is introductory and sums up the pupils' plant experiences, and leads into the experimental work of Sections II and III, which are upon "The General Nature of the Work and Structure of Plants." In these sections class experiments are performed by the teacher or some of the pupils, each pupil writing careful descriptions of the experiment. In an agricultural region constant collateral experiences should be brought into this section. The purpose is to give a clear notion of the working plant as a unit. This work is introduced by experiments in transpiration, root pressure, stem work in supporting and conducting, stem and leaf water lifting experiment, etc. Then follows an outline study of the structure of roots, stems, leaves and flowers each designed to contribute to the whole working unit—the plant. In connection with the leaf work the work of photosynthesis in making plant foods is introduced; and in connection with the flower, seed formation and the general problems of seed distribution, food storage, etc., are begun in such a way that each may be ready for more detailed treatment in subsequent sections. General problems of dependent plants, parasitism, saprophytism, decay, bacteria in relation to disease, and agriculture are presented.

Sections IV to VIII are devoted respectively to Roots; Leaves and Stems; Flowers; Seeds and Seed Distribution; and Seedlings.

Having worked with seed plants until we have developed point of view, method of work, some knowledge of plant structure and processes, and their relation to practical life, we may logically attack the great groups of plants in order of increasing complexity asking of each group the questions, How do these plants live? With what structures is their work done and how do they act? How are these plants affected by other living things including man, and how do they affect them? Therefore Sections IX to XVI treat respectively *Algae; Fungi; Bacteria; Liverworts; Mosses; Ferns; Gymnosperms; Angiosperms.*

Finally the plan I have in mind recognizes that while it is important that economic, agricultural and industrial aspects of plants should be presented in the regular work, there are certain topics that seem to demand special treatment, this treatment in each case based upon the references previously made in course of the work. For example, the topic of *Forestry* will have been briefly presented in connection with the section upon stems, but demands fuller treatment. So with *Plant Breeding, Plants and the Industries,* (agriculture, horticulture, etc.), and possibly *The Geological History of Plants.*

The first part of the above outline may be used for a half-year course, though I most sincerely hope it will not long be necessary to provide for a half-year course. "But," says someone, "if we use this outline for a half-year course our pupils will study seed plants almost exclusively, and we believe they should know something about ferns, mosses, etc." We should agree upon this point, but I know of no way whereby students can in a half year do the amount of work that should constitute a year's work, and the sooner we cease trying to delude ourselves into thinking that we have accomplished just as much by touching all the topics that should be in a year's course, the better will it be for the students and for botany. A half year's course will be a much more acceptable and respectable thing when it presumes to cover but a half year's material. A year of botany cannot be done in a half year.

VI. The Place of Field Work, the Laboratory, Text-Book and Teacher.

a. Field work. Unless students have seen or may see a good many plants in their native growing places, it is impossible to gain the best results in the course in botany. Much field work may profitably be used in any general botanical course, and some such direct out of door contact with plants is essential to proper interpretations of indoor work. With these statements in mind, therefore, I trust I shall not be misunderstood in making the following statements:

It is impossible and undesirable to do the amount of field work often recommended for high school classes in botany. The organization of the high school, the duties of students before and after school, the limits in transportation facilities, etc., in many high schools often make it simply impossible to take many class field trips. Furthermore, I believe that no small percentage of the field trips we have had have been so conducted as to cheapen and undignify the entire course in botany. If a field trip is worth taking, it is worth planning with great care, and worth following up in later indoor work. Indeed, the nature of the field trip with its peculiarly dangerous by-paths is such that it needs to be planned with more care than a class room exercise. In many cases it is quite the reverse, and instead of helping the course has proved a means of lowering the standards of the course. I believe in well planned field trips, but not in purposeless jaunts. Those have a most excellent place, but not in the course in botany.

b. The laboratory is a substitute for out of doors. It is a place where we may control working conditions, where plants may be grown and studied often better than could be done out of doors. So long as people must be taught in classes, always perhaps in public schools, we shall need places where several may work under a common supervision, and the laboratory furnishes such a place. Because of its stimulus, if properly used, many students will take individual and volunteer field trips, or even excursions to remote regions and these are of great value.

Laboratory apparatus, not much of which is absolutely essential though much is extremely helpful, is to be looked upon entirely as a means toward finding out about plants.

c. *The text-book* should be a source of information upon and organization of the materials in some way touched upon in laboratory and field work. The botany text-book should con-

tain much of the general knowledge about plants. It should be read copiously. It must be interpreted by means of first-hand contact with plants. It is a mistake to assume that all botanical knowledge should come from laboratory or field. From those sources we can get only a part of such knowledge, but that part makes our reading full of meaning.

d. *The teacher.* After all is said regarding the principles that should determine the course, the plan for the course, the field, laboratory and text-book, it must be recognized that the teacher is the factor that determines whether the course will succeed or fail. A good teacher will do pretty good work in botany even if his laboratory and field opportunities do not suit him; and if the text-book is not to his liking, he can strengthen the points of weakness. A poor teacher will not give the best course even if given all he may ask in text-book, laboratory, and field opportunities.

1. The good teacher, however, is not handicapped by having some clear, definite, purposeful plans upon which he is proceeding—indeed, he will always have them. The teacher should be clear upon the educational purposes of his subject, and have a definite plan for realizing those purposes. He should know enough of his subject that his knowledge will be a source of constant stimulation to his students and to himself, enough to give him freedom from the embarrassments of great ignorance. A thorough knowledge of the details of some particular field in either botany or zoölogy. It is assumed also that some knowledge of other related sciences is necessary. Too often, however, the teaching of botany is left to a person who is primarily the teacher of physics and chemistry, and who in some cases has no preparation in botany. Due to the presence of the life factor and the complications of the changing responses it makes in changing environments, it would seem better to leave physics to a botany teacher who is not prepared in physics than leave botany to a physics teacher not prepared in botany. This conclusion may be due to a prejudice on the part of one engaged in teaching botany. It must be recognized that in all but the largest high schools the "teacher of sciences" needs to be well prepared in both physics and botany as well as in other sciences.

The field of botany and zoölogy have so many things in common that the teacher of either subject should have a good general knowledge of the other. Furthermore if he has an intimate knowledge of the details of some subdivision of one field he will

have been introduced to the method of research in such a way as to enable him to appreciate the difference between the known and the unknown. Some appreciation of the limits of knowledge in one field will help greatly to remove a feeling of necessity of knowing about all points that may arise in the process of teaching. Professional integrity has been seriously interfered with on the part of a good many people who could not be expected to know what they felt they should know. The old teacher said: "John, what is the function of the spleen?" John replied, "Professor, I knew that this morning, but I have forgotten." "You rascal," said the teacher, "all the world is wanting to know and you have forgotten it."

2. The teacher should have definite ideas concerning the function of botany in high school education. This does not mean that to be a good teacher of botany we must have compassed the territory of educational theory in general, though some such work would doubtless be helpful. But one should know what he is going to try to do with botany if he assumes to teach it. We do occasionally arrive at places to which we did not intend to go, but we very much more often arrive at objective points selected before the arrival. Aimless botany teaching cannot produce most valuable results.

3. The teacher needs to know pupils of the age to whom botany is to be taught. He needs to know their general ability, their ways of thinking of things, and the amount of botanical data upon which he may begin to build. There are still a good many college graduates who do the high school boys and girls the honor of supposing them to be as mature as was he when he took his college courses in botany. He attempts to teach them the quality and quantity of material that he got in college, and in the same way. The teacher needs to know the minds of the pupils well enough to enable him to defend them against some of the botany text-books by means of which courses entirely too heavy are presented to high school pupils. So many botany teachers are afflicted with the "malady of total recall."

4. The teacher should have an active interest in teaching botany and in studying problems related thereto. A truly active nature interest on the part of the botany teacher is infectious, just as truly as dead and uninteresting teaching helps to develop immunity to nature interest. Nearly all pupils possess an inherent interest in plant life. This will give rise to all sorts of spontaneous expression if the teaching is of proper interest.

PROBLEM DEPARTMENT.

IRA M. DELONG.

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

124. *Proposed by Walter L. Brown, Fancher, N. Y.*

A plank 16 ft. long with a weight of 196 lbs. on one end balances across a fulcrum placed one foot from the 196 lb. weight. What is the weight of the plank?

Solution by T. M. Blakslee, Ph.D., Ames, Iowa.

I. If x=weight of the plank, acting through its mid-point with lever arm 7, while the weight of 196 has the lever arm 1, the equation of moments is:

$$7x=196, \text{ and therefore } x=28.$$

II. One foot of the long end next to the fulcrum balances the one foot of the short end, the remaining 14 feet of plank weigh $\frac{7}{8}x$ and has a lever arm 8. Therefore

$$\frac{7}{8}x8=196, \text{ and } x=28.$$

III. The short end and the 196 tend to cause rotation of one sign, the long end that of the other sign:

$$(\tfrac{15}{16}x)\ (7\tfrac{1}{2}) = (x/_{16})\ \tfrac{1}{2} + (196)\ (1).$$

From the latter equation it follows also that $x=28$.

II. *Solution by Eugene R. Smith, Brooklyn, New York; and Iva Ernsberger, Meridian, Miss.*

Let the weight of the plank be x lbs per ft. Then the equation of moments is:

$15x\times7\frac{1}{2}=x\times\frac{1}{8}+196\times1$, and $x=1\frac{3}{4}$. The weight of the plank is $16x=28$.

125. A and B entered into partnership and gained \$200. Now 6 time A's accumulated stock (capital and profit) was equal to 5 times B's original stock; and 6 times B's profit exceeded A's original stock by \$200. Required the original stock of each. *(Wells' University Algebra, 1880, p. 130).* Solve by linear equations.

I. *Solution by G. E. Congdon, Hiawatha, Kansas.*

Let x=B's profit,

then $200-x$=A's profit.

From second condition,

$6x-200$=A's original stock

$6x-200+200-x$=A's accumulated stock, or $5x$

From first condition,

$30x$=five times B's original stock,

Therefore $6x$=B's original stock, and his profit is one-sixth of his original stock; and

$200-x$ (A's profit)$=1/6\ (6x-200)$
or, $1200-6x=6x-200$
$12x=1400$
$x=116\ 2/3$
$200-x=83\ 1/3$
$6x-200=\$500$ A's capital.
$6x=\$700$ B's capital.

II. *Solution by A. Darnell, Detroit, Michigan.*

Let A=A's capital and a his gain; B=B's capital and b his gain. Then $6(A+a)=5B$; $6b-A=200$; $a+b=200$. Eliminating A and a gives $B=6b$, and therefore the investment was six times the profit, that is, the investment was \$1,200. Since $a=A/6$ we have from the first of the above equations $7A-5B=0$. From this and $A+B=1,200$, it follows that A=500 and B=700.

III. Solution by O. R. Sheldon, Chicago, Ill.

Let x=A's original stock, m=B's gain and r=rate of gain. Then

$$6\ (x+200-m)=5m/r;\ x+200=6m;\ 200-rx=m.$$

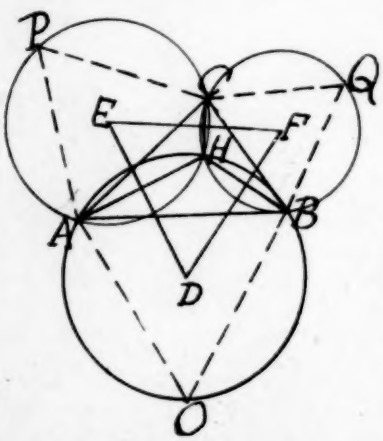
These equations give $30m=5m/r$, $r=1/6$ and $x=500$, $200/(r-x)=700=$ B's stock.

Geometry.

126. *Proposed by A. W. Rich, Worcester, Mass.*

Given a triangle ABC on whose sides as bases are drawn isosceles triangles whose base angles are 30°. Prove that the triangle formed by the vertices of the isosceles triangles is equilateral.

Solution by G. B. M. Zerr, Ph.D., Philadelphia, Pa.



Let ABC be the given triangle. Construct upon the sides of ABC the equilateral triangles OAB, PAC, QBC. The centers D, E, F of the circumcircles of these triangles are the vertices of the given isosceles triangles. Let the circles APC, BCQ meet in H. Now AHCP is inscribed in a circle and the angle AHC=120°. Similarly angle BHC =120°. Hence AHB=120°, angle AHB+O=180°. Therefore AHBO is inscribed in a circle and H is in the circle about AOB.

EF bisects CH; ED bisects AH; DF bisects BH, hence angle CEH $=2\times$HEF, angle AEH=2 DEH, and AEC=2 DEF. Therefore angle DEF=60°. Similarly angle D=F =60° and triangle DEF is equilateral.

Remark by T. M. Blakslee, Ph.D., Ames, Iowa.

This theorem holds also if the isoseles triangles are drawn *inwardly*.

Trigonometry.

127. *Proposed by W. T. Brewer, Quincy, Ill.*

A man 6 ft. high stands in front of a looking-glass resting on the ground and leaning at an angle of 30° against the wall, from which he is 10 ft. distant. What must be the length of the glass that he may just see his whole person? *(Parkison's Optics, 1870, p. 257.)*

Solution by W. T. Malone, Fern Hill, Washington.

Let $2l$ = length of glass; it forms with the wall and ground a right triangle whose legs are l and $l\sqrt{3}$. The ray from the feet that is deviated least by reflection is parallel to the ground and makes an angle of incidence of 30°, and therefore with the reflected ray an angle of 60°. A perpendicular from the eye to the ground forms with these two rays a right triangle similar to the one formed by the glass, and having for legs $10-l$ and 6. Hence

$$\frac{6}{l\sqrt{3}} = \frac{10-l}{l}. \quad \therefore 2l = 4(5-\sqrt{3}) = 13.072 \text{ ft.}$$

Only $2\sqrt{3}$ ft. of the mirror is in actual use; its great length is necessary to reach the wall.

CREDIT FOR SOLUTIONS RECEIVED.

Algebra 118. Eva Ernsberger, Louis Lindsey, Eugene R. Smith, I. L. Winckler. (4)

Algebra 119. I. L. Winckler. (1)

Geometry 120. Eugene R. Smith, I. L. Winckler. (2)

Geometry 121. Eva Ernsberger, Eugene R. Smith, J. F. West, I. L. Winckler. (4)

Applied Mathematics 122. I. L. Winckler. (1)

Algebra 123. Henry A. Campbell, G. E. Congdon, A. Darnell, Eva Ernsberger, D. L. Hines, Irvin E. Kline, Frank M. Life, Max A. Plumb, G. B. M. Zerr. (9)

Algebra 124. T. M. Blakslee (3 solutions), Walter L. Brown, Henry A. Campbell, G. E. Congdon, Eva Ernsberger, D. L. Hines, Jno. A. Hodge, Frank M. Life, Louis Lindsey, W. T. Lofland, Max A. Plumb, A. Haven Smith, Eugene R. Smith, I. L. Winckler, G. B. M. Zerr. Also two incorrect solutions. (19)

Algebra 125. Walter L. Brown, Henry A. Campbell, G. E. Congdon, A. Darnell, Eva Ernsberger, A. M. Harding, D. L. Hines, Louis Lindsey, Frank M. Life, W. L. Malone, F. W. Runge, O. R. Sheldon (2 solutions), G. B. M. Zerr. (14)

Geometry 126. T. M. Blakslee (5 solutions), W. T. Brewer (2 solutions), Walter L. Brown (2 solutions), G. E. Congdon, A. Darnell, Eva Ernsberger, Frank M. Life, W. L. Malone, I. L. Winckler, G. B. M. Zerr. (16)

Trigonometry 127. Walter L. Brown, Eva Ernsberger, Frank M. Life, W. L. Malone, Eugene R. Smith, I. L. Winckler, G. B. M. Zerr. (7)

Total number of solutions, 77.

PROBLEMS FOR SOLUTION.

Algebra.

134. Factor $(x+y+z)^5-(x^5+y^5+z^5)$.

135. *Proposed by I. L. Winckler, Middlebury, Vt.*

Solve by Quadratics,

$$x^2-y^2=a^2,\ x^3+3xy^2=b^3.$$

Geometry.

136. *Proposed by C. Z. Aughenbaugh, Woodstock, Ill.*

ABCD is a parallelogram, Y any point on AB between A and B, X any point on CD between C and D. Let PD intersect AX in P, and YC intersect XB in Q. Let PQ intersect AD in M and BC in N. Prove that MN divides the parallelogram ABCD into two equal parts.

137. *Proposed by E. L. Brown, M.A., Denver, Colo.*

The lengths of the sides of a triangular field are a, b, and c feet. A farmer commences at one corner in the morning and plows m furrows n inches wide around the field in the forenoon. How many furrows must he plow around the field in the afternoon to turn over the same area as in the forenoon?

138. *Proposed by Arnold Emch, Ph.D., Solothurn, Switzerland.*

Two parallel planes intersect a sphere in circles whose diameters are $AB=c_1$ and $CD=c_2$, the distance between the planes being h. Find the intercepted volume as the difference of two spherical segments.

DEPARTMENT OF SCIENCE QUESTIONS.

By Franklin T. Jones,

University School, Cleveland, Ohio.

It has recently been repeatedly asserted that the physics teachers of the country, especially in small schools, are laying particular stress on "accurate quantitative experiments." Any information on this matter will be greatly appreciated by the editor of this department.

Please send in lists of the laboratory exercises you will use this year. Numerous and representative answers are desired.

Experiments performed at the Massachusetts Institute of Technology show that a piece of paper of a similar quality to that upon which the magazine School Science and Mathematics is printed would need to be about one eighth of an inch square in order to furnish one calorie of heat upon burning in the open air.—*J. C. Packard, Brookline, Mass.*

A steel spring is wound up. It is then dissolved in acid. What becomes of the energy which the spring is supposed to possess on account of its tension?

Evidently the solution formed by the action of the acid on the coiled spring contains no more energy than if the spring were uncoiled. The coiled spring, therefore, contains no more energy than the uncoiled spring, or, more accurately, the sum of its energies is zero, the energy given to it in coiling having been dissipated as heat. It has, however, by virtue of its molecular attractions and repulsions, the capacity of transforming heat energy into mechanical energy when unwinding.

The idea may be made more clear by the following simple experiment: Stretch a flat rubber band while placed in contact with the lip. It will be found to grow decidedly warmer, showing that the applied mechanical energy is transformed into heat. Allow the band to contract while in contact with the lip and it will be found to grow cooler, showing that heat is absorbed by the band and transformed into mechanical work.

E. E. BURNS,
Medill High School, Chicago, Ill.

A man weighs 150 pounds on a spring balance at the equator. What would he weigh at the north pole? On the moon? On the sun? What would he weigh at each of these places on a platform balance?

Solution by Chas. H. Korns, Bradford, Pa.

By means of careful pendulum experiments performed in various latitudes, it has been determined that gravity at the north pole exceeds that at the equator by approximately 1/190. 1/190 of 150 pounds = .7894+pounds.

∴ the man would weigh 150.7894+ pounds at the north pole.

By the law of universal gravitation,

$$\frac{\text{The Force of Gravity on the Earth's Surface, } Fg}{\text{The Force of Gravity on the Moon's Surface, } F'g} = \frac{\frac{Mm'}{d^2}}{\frac{M'm}{(d')^2}} = \frac{Mm(d')^2}{M'md^2},$$

Where M = mass of the earth, M′ = mass of the moon, m = mass of the body under consideration, d = radius of the earth, d' = radius of the moon. The mass of the moon is 1/81.5 of the earth's mass, and 1081 miles = moon's radius. Then if we take m equal to unity, we have,

$$\frac{Fg}{F'g} = \frac{81.5(1081)^2}{1(3958.8)^2} = \frac{6.076}{1} \text{ or approximately } \frac{6}{1}.$$

∴ the man would weigh 1/6 of 150 pounds = 25 pounds on the moon.

By similar calculation it can be shown that an object weighs approximately 27 times as much on the sun as on the earth. ∴ the man would weigh 27×150 pounds = 4050 pounds on the sun.

On a platform balance he would weigh the same at the equator as on the spring balance, *i. e.*, 150 pounds, since such balances are commonly used to determine weight. The size of the weights used would necessarily need to be determined by comparison with a spring balance, however. At the north pole, on the moon, or on the sun there would be no change in the man's weight as recorded by the platform balance

and these same weights. Thus the man would weigh 150 pounds on the platform balance at each place. This is true because the weight of the man and of the counterpoising weights is altered in the same ratio when moved from the equator to the poles, to the surface of the moon, or to the surface of the sun.

Discussion: Since weight is the measure of the force of gravitation, a platform balance does not give the correct weight unless the counterpoising weights have been determined as to mass, by comparison with a spring balance for that particular latitude and altitude.

In each of these cases with both the spring and platform balances there would be a slight variation due to the differences in atmospheric conditions. This brings up the principle of buoyancy as here related —the true weight of any object can only be determined either by weighing in a vacuum or by making a correction for the buoyancy of the air. The moon would furnish ideal conditions for weighing, having no atmosphere, whereas the object weighed on the sun would appear remarkably lighter, owing to the very dense atmosphere. This effect might be eliminated in weighing with platform balances by having the volume of the counterpoising weights equal to that of the object to be weighed.

A noteworthy point in connection with the variation of gravity on the earth's surface is that it is at variance with the law of gravitation, as the following shows:

The total loss from pole to equator as shown by pendulum experiments is 1/190.

The loss due to centrifugal force:

$$\text{Fc} = \frac{\text{W}v^2}{g\text{R}}. \quad v = \frac{2\pi\text{R}}{\text{T}} \quad \therefore \text{Fc} = \frac{4\pi^2\text{RW}}{g\text{T}^2}$$ where R = equatorial radius, W=1, g=32.16, and T=number of seconds in sidereal day. Substituting we get 1/289. 1/190 — 1/289 = 1/555 = loss due to change in radius, etc.

The loss due to change in radius:

$$\frac{\text{F}g}{\text{F}'g} = \frac{\frac{\text{M}m}{d^2}}{\frac{\text{M}'m'}{(d')^2}}$$, but M = M′ = mass of earth, and $m = m' = 1$

$$\therefore \frac{\text{F}g}{\text{F}'g} = \frac{(d')^2}{(d)^2}.$$

Substituting, we get the relative values of g to be as 1 to .991289+.

The loss from equator to pole is therefore 1/115, which is not far from five times the value determined by the pendulum experiments.

This variation is doubtless due to the flattening of the earth and to irregularities in its density.

GEOMETRY REPORT.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

An edition of fifteen hundred copies of the preliminary report has been exhausted, and it is the intention of the committee to issue a complete revised report in the near future. The following is a table of contents of the preliminary report:

1. Introduction. The proposals of the committee are meant to be evolutionary, not revolutionary, in tendency; and each suggestion is intended as one which could be adopted without departing far from current texts and methods. The committee expects no sudden drastic reforms in the teaching of geometry, but hopes that those who may have been accustomed to look upon current texts as ideal and their logic as unassailable will tolerate criticism and concede the desirability of reforms. In any event, it is not advised that many changes be introduced hastily, but that, so far as possible, the teacher become familiar with each change before putting it into practice in teaching.

2. Do not attempt to define the terms Point, Line, Surface, Plane, Straight, Whole, Part, Between, In, Through, Divide, etc.

3. Use the term "congruent" instead of "equal" to indicate figures which are identically equal.

4. Use the term "ray" for a "half line," "sect" for "line segment," "circle" for "circumference."

5. Use geometrical "assumptions" instead of the usual unintelligible "axioms."

6. Introduce definitions when required instead of *en bloc*, grouping and summarizing later if desired for the purpose of review and for showing their relations.

7. When a step of a demonstration is derived from an inspection of the figure, the authority for this step should be acknowledged.

8. Avoid redundancies in constructions and statement of propositions.

9. Do not use the customary, but wholly fallacious, method of proving that the area of a rectangle is the product of the lengths of two adjacent sides. *Do not attempt a logical treatment of incommensurable magnitudes or of limits.* Assume all cases in propositions involving incommensurables and all propositions involving limits.

10. Applications.

11. Relation to algebra.

12. Teach the history of the subject, and especially of important theorems.

13. An elementary course in geometry should be followed by an advanced course.

14. Use diagrams showing the relations and interdependence of propositions.

15. A list of fundamental theorems and constructions.

16. The pedagogical value of recreations.

Many sections of the report for plane geometry apply equally, with little or no modification, to solid geometry. For example, sections 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 16. With regard to the recommendation that the idea of congruence be aided by experiment, it may be remarked that in solid geometry it is probably impossible, without appeal to experience, to define congruent solids so as not to include symmetric solids—a difficulty not encountered in dealing, as in Hilbert's Foundations, with plane geometry.

Solid Geometry.

1. An appreciation of sound, closely connected reasoning should be acquired in some department of mathematics, and it is believed that a proper training in plane geometry will go far toward achieving this result. The student will have learned by paradoxes not to rely too much upon appearances, and that he should, if possible, prove many things which at first sight he might be inclined to accept with little consideration. One of the greatest dangers in all reasoning—that of making assumptions implicitly and unconsciously—will thus be minimized and more latitude may be allowed in subsequent work.

2. By explicitly assuming many of the propositions in solid geometry where little is accomplished by a formal proof except to cater to an erroneous view that there is an unbroken continuity in the subject, time will be found for assisting in overcoming the initial difficulties of visualizing solid figures and for developing space intuitions by means of simple concrete forms. The probability that two non-co-planar lines have a common perpendicular is very clearly brought out with two strings: the properties of two symmetric figures may be shown by mirrors or paper figures; stereoscopic views would prove invaluable aid; the volume of a sphere as one third the product of the surface and a radius is strikingly illustrated by cutting off the corners from a circumscribing polyedron; experimental verification may well take the place of Euler's theorem concerning the edges, vertices, and faces of a polyedron, etc. At the same time, no student who has profited by his work in plane geometry will mistake these *aids* for mathematical *proof*.

3. Assume Cavalieri's theorem concerning the equality of solids when corresponding sections by all planes parallel to a fixed plane are equal, and thus prove the equality of prisms having equal bases and altitudes; also of pyramids, cylinders, cones, and frustums, as well as the equality of a sphere to the solid bounded by a certain cylinder and two inscribed cones. This will also avoid the customary proof of the equality of two pyramids by the method of exhaustions, with its inherent philosophical difficulty.

4. Considerable attention should be given to exercises in mensuration: the application of theorems to concrete cases gives fixity to the ideas and affords a firmer grasp of the subject, as well as giving much needed practice in discerning relations which might otherwise be overlooked. At the same time, they give admirable drill in algebraic operations, and an excellent opportunity of applying approximate methods in multiplication and division.

"A satisfactory course of instruction should include:

(1) The determination of the surfaces and volumes of the elementary solids.

(2) A discussion of the relations of points, lines, and planes in space."

5. The following definitions are suggested:

A Prismatic Surface is the surface generated by a (straight) line which moves so as to constantly intersect (the perimeter of) a fixed polygon not co-planar with it, and which remains parallel to its original position.

Note that by changing the word "polygon" to "curve" we have the definition of a Cylindrical Surface.

The moving line is the generatrix, the fixed polygon the directrix, of the surface. The generatrix in any position is an element. The elements through the vertices of the polygon are the edges of the surface.

A Right Section of a prismatic surface is the section by a plane perpendicular to an edge (and therefore to all the edges).

The solid bounded by a prismatic surface and two parallel planes (intersecting the surface) is a Prism.

A Pyramidal Surface is the surface generated by a (straight) line which moves so as to interesect constantly (the perimeter of) a fixed polygon and which passes through a fixed point not in the plane of the polygon. (It will be seen that the surface described consists of two parts, called nappes, on opposite sides of the fixed point, or "vertex".)

Note that by changing the word "polygon" to "curve" we have the definition of a Conical Surface.

The moving line is the generatrix, the fixed polygon the directrix, of the surface. The generatrix in any position is an element. The elements through the vertices of the polygon are the edges of the surface.

The solid bounded by a pyramidal surface and a plane intersecting all the edges on the same side of the vertex is a Pyramid. (The circumstances under which a plane will interesect all the edges on the same side of the vertex would be a good problem for advanced students.)

A Solid Angle is a figure generated by a ray which moves so as to intersect constantly a fixed polygon, and whose vertex is a fixed point not in the plane of the polygon.

A Sphere is the locus of points equidistant from a fixed point.

6. In view of the fact that students frequently fail to remember that certain theorems are true universally, while others are true only in plane geometry, it would be well to call attention to these different classes while studying them in plane geometry. For example, the student usually has difficulty in solid geometry in unlearning that at a point in a line there is one, and only one, perpendicular to the line. This will be minimized if, in proving and using such a theorem as "Two lines perpendicular to the same line are parallel," or "Two lines

parallel to the same line are parallel," it is carefully pointed out that the theorem either is not true in solid geometry, or will require additional proof. For example, the first theorem might be stated, "In a given plane, two lines perpendicular to the same line are parallel."

7. In view of the inherent difficulty in dealing with limits, it is recommended that no proofs be required for deducing the areas of curved surfaces from plane areas, or the volume of solids bounded by curved surfaces from polyedra (with plane faces). Illustrate the formula for the volumes of cylinders, cones, and frustums of cones, and the lateral areas of right cylinders, cones, and frustums by using the corresponding inscribed and circumscribed polyedra, stating that satisfactory evidence of the truth of this formula will be found in more advanced mathematics. It will not be difficult for students to see a reasonableness in the formula, and at the same time his sense of logical rigor will not suffer. In passing, it may be noticed that current "proofs" of the formula for the lateral area of an oblique cylinder with circular bases overlook the fact that a right section of such a cylinder is not a circle, but an ellipse, the treatment of which does not belong to elementary geometry. Also, while the length of a circle may be defined in terms of an inscribed polygon, the number of whose sides is repeatedly doubled, giving rise to a definite series of algebraic operations, there is no corresponding method of defining the surface of a sphere in terms of a circumscribed or inscribed polygon, or corresponding series of approximations for obtaining the value of π.

8. The following, with applications, corollaries, easy extensions, and the theorems necessary to establish them, is suggested as a tentative list of fundamental theorems:

1. Determination of a plane (four ways).
2. The intersection of two planes is a (straight) line.
3. Lines parallel to the same line are parallel.
4. If two lines are perpendicular to a third line at the same point, every line through this point in the plane of the two lines is also perpendicular to the third line.
5. Planes perpendicular to the same line have no common point.
6. Any plane containing a line perpendicular to a given plane is perpendicular to the plane.
7. The intersections of two parallel planes with a third plane are parallel.
8. If two intersecting planes are each perpendicular to a given plane, their intersection (intersects and) is perpendicular to the given plane. (It may be noticed that to prove the intersection of the line and the given plane is as difficult as to prove that they are perpendicular, although the intersection is, as a rule, assumed.)
9. The projection upon a plane of a line not perpendicular to it, is a line.
10. Every plane containing only one of two parallel lines is parallel to the other.

11. Of the sects from a point without a plane to a point within it.
    (*a*) the perpendicular is the least;
    (*b*) those with equal projections are equal; and the converse;
    (*c*) those with the same inclination are equal; and the converse.
12. Two lines, not co-planar, have one, and only one, common perpendicular.
13. Parallel planes divide transversal lines proportionally.
14. The locus of points equidistant from two interesecting planes is the pair of planes bisecting the angles formed by the given planes.
15. If two angles have their sides respectively parallel, and lying on the same side (or on opposite sides) of the line through their vertices, they are congruent.
16. The sum of any two face angles of a triedral angle is greater than the third face angle.
17. The sum of the face angles of any polyedral angle is less than four right angles.
18. Parallel plane sections of a prismatic surface are congruent.
19. Parallel plane sections of a pyramidal surface are similar figures, whose linear dimensions are in the same ratio as the distances of their planes from the vertex.
20. The volumes of prisms, pyramids, and frustums of pyramids.
21. The surfaces of prisms, regular pyramids, and frustums of regular pyramids.
22. All plane sections of a sphere are circles.
23. A plane perpendicular to a radius of a sphere through its outer extremity contains no other point of the sphere.
24. The arcs joining a pole to any point of its circle are congruent.
25. If one spherical triangle is the polar of a second triangle, the second triangle is also the polar of the first triangle.
26. The ratio of the volumes of two similar solids is the cube of the ratio of any two corresponding linear dimensions.
27. The ratio of the lateral area of two similar solids is the square of the ratio of any two corresponding linear dimensions.
28. The volume of a sphere (see section 3).
29. Give examples in the computation and illustration of the formulas for the volumes of cylinders, cones, frustums of cones; the surfaces of right cylinders, cones, and frustums of cones; the surface of a sphere, of lunes, zones, and spherical triangles.
30. Describe and discuss the regular solids.

These propositions are numbered merely for convenience of reference. It is not intended to imply advice concerning the wording or arrangement of propositions.

9. It will be interesting to compare many theorms and constructions of solid geometry with those of planes; for example:

A circle can be inscribed in any triangle.	A sphere can be inscribed in any tetrahedron.
Two lines parallel to the same line are parallel.	Two lines parallel to the same line are parallel.
The diagonals of a parallelogram bisect each other.	The diagonals of a parallelopiped bisect each other.
Parallel lines intercepting congruent sects on one transversal intercept congruent sects on every transversal.	Parallel planes intercepting congruent sects on one transversal intercept congruent sects on every transversal.
The locus of points equidistant from two intersecting lines is the pair of lines bisecting the angles formed by the given lines.	The locus of points equidistant from two intersecting planes is the pair of planes bisecting the angles formed by the given planes.

The members of the committee will be pleased to receive any criticisms of the foregoing report, or further suggestions.

G. W. GREENWOOD, chairman, Dunbar, Pa.
C. A. PETTERSON, Jefferson High School, Chicago, Ill.
C. E. COMSTOCK, Bradley Polytechnic Institute, Peoria, Ill.
C. W. NEWHALL, Shattuck School, Faribault, Minn.

SCHOOLS AID IN CONSUMPTION FIGHT.

Children Are Taught How to Prevent Disease.

New York, Dec. 3.—As a result of the great campaign against tuberculosis now being carried on throughout the world, many of the public schools in the United States are taking a new departure in teaching to the children the nature, causes, dangers and prevention of consumption. A text-book entitled "Simple Lessons on Tuberculosis or Consumption" has just been placed in the seventh and eighth grades of the District of Columbia. The Massachusetts educational authorities, acting under a law of the Legislature of 1908, are establishing courses of instruction on tuberculosis in all of the schools of the state. In addition to these public movements many of the private organizations throughout the country have established, and are establishing, open-air schools for consumptive children, it being estimated that about two per cent of the pupils in the larger city schools have tuberculosis.

The first public school for consumptive and pre-consumptive children to be established in the United States was opened in Providence, R. I., last January. The sessions were held entirely in the open, and the benefits of the fresh-air treatment were combined with the teaching and training of the public schools.

This experiment led to other movements, both public and private. The Brookline Anti-Tuberculosis Society opened a school for tuberculous children in July which is still successfully conducted. In Boston a school for consumptives was opened under private auspices in July, it being the intention to keep it open for the summer months

only, but so successful were the results of this work that the city school authorities recently decided to take over the work and set aside a permanent building for this purpose. In Pittsburg a similar school was opened in September, and the marked benefits which the children have already received from this training have led to its enlargement. The Board of Education of New York City has just granted a teacher to the Bellevue Hospital Day Camp for the purpose of conducting a school there, and a consumptive teacher has been secured to teach the consumptive children. This school will be conducted on the deck of an old ferry-boat. In all of these schools the children are kept in the open air all day long. Most of the buildings used are opened on three sides and are so constructed as to furnish unlimited supplies of fresh air without draughts. Desks, blackboards, and other paraphernalia are provided in these schools just the same as in the regular institutions. The children study and recite in the open air, even during the coldest weather, and the percentage of colds among them is far smaller than children in the ordinary public schools. In most of these fresh-air schools soapstones are provided for keeping the feet warm in cold weather.

In addition to these specially constructed schools several of the States have required that the important facts about tuberculosis be taught in the lower grades of the public institutions. Michigan was the first State to adopt measures of this kind. By an act of 1895, the public schools are required to give instruction on the nature of tuberculosis and other infectious diseases. In New Jersey progressive steps are being taken by teaching the children in the schools a set of aphorisms on consumption. In Massachusetts a section on the nature, dangers and prevention of consumption is being inserted in all of the physiologies. In the District of Columbia a special text-book has been provided in which instruction is given concerning sleeping in the open air, the dangers of spitting, the way to prevent consumption, and other kindred topics. Dallas, Tex., is the latest city to adopt the method of teaching children about consumption in the schools, and within a few days a "Tuberculosis Primer" will be in the hands of every pupil in the public schools. In North Carolina a separate section on tuberculosis, placed in all the physiologies, is taught to all of the children. In Baltimore steps are being taken to carry on a systematic campaign of education among the school children by means of lectures and circulars. Many other cities of the country are following this plan. A petition has been sent to the Governor of South Carolina requesting that a text-book on tuberculosis, similar to that used in Washington, be placed in the public schools. Several of the other States are also taking steps along similar lines.

This movement for the popular education of school children on the causes and dangers of consumption is receiving a great impetus, and experts on this subject conclude that within five years the majority of children in the United States will be taught concerning the evils and dangers of tuberculosis before they leave the lower grades of the public schools.

THE TEACHING OF BIOLOGY.

DR. C. A. SHULL.

The following letter, which is one of those that have come as a response to the "Symposium on the Teaching of Biology," presents a point of view not yet presented in the symposium. Further contributions to this symposium should be forwarded to the editors at an early date. OTIS W. CALDWELL.

MY DEAR DR. CALDWELL: I have read with great interest the biological symposium, and it has undoubtedly stimulated a great deal of thought among those interested in the teaching of biology in the secondary schools.

There are some things to be said in favor of a year course in general biology, if we *must* confine the work to a year, and they have been ably said. But it seems to me that the question of limiting the study of biology to one year only, is a debatable one; and in my own experience the weight of all practical evidence is in favor of a larger amount of biological work.

Of one thing I am firmly convinced. It is impossible to secure satisfactory results with one third of a year each of zoölogy, botany, and physiology. And the half-year course is little better with young students. Any one of these subjects is sufficiently comprehensive and comprehensible, and of sufficient importance practically and theoretically to the layman as well as to the professional biologist, to warrant the extension of the time devoted to it at present.

However, such an extension is impossible unless the work in other lines can be condensed. For the fifteen or sixteen units of work are conceded by everyone to be as large as should be required for entrance to the college or university. I believe that such a condensation of the work in other fields could be made, with advantage in the direction of genuine scholarly attainments. If the courses in ancient language were combined with those in English with the motive of giving to the student the key to the origin and derivation of English words, I believe that both the languages and the English would be much improved as culture studies.

I recognize that there is a certain value in the study of the Grecian and Roman classics, but I question whether that value is at all commensurate with the time usually devoted to their study.

These suggestions may seem unorthodox, but I believe, if carried out, they would lead to a stronger, more unified, and more practical course, which would permit the extension of the time devoted to biological sciences in a measure befitting their value as culture studies, and their economic and theoretical importance to mankind.

Very sincerely yours,

CHAS. A. SHULL,

Professor of Biology, Transylvania University, Lexington, Kentucky.

RECORDS BY TALLY STICKS.

In the course of a recent address given before the Lawrence (Mass.) Textile School, Mr. Samuel S. Dale, editor of the *Textile World Record*, gave the following interesting account of the old English Tally Sticks:

R. P. W.

"In 1834 both Houses of Parliament at London were destroyed by a fire, and, with them, all the basic standards of weight and measure for the British Empire. That fire was caused by burning a lot of old tally sticks in the furnace of the House of Lords. Many of you may ask, as I did when I first heard of this event: 'What is a tally stick?' Before writing on paper had come into general use, the accounts of the British Exchequer with depositors were kept by tally sticks. When a person deposited money with that institution the clerk cut notches in a stick, which was about 8 inches long and ⅜ inch square. There was a deep notch for each pound sterling, a small notch for each shilling, and a scratch or slit for each penny of the amount deposited. The depositor's name and the date were then written on two sides of the stick.

"The tally clerk next sawed the stick half in two at a point a short distance from the end, and then split it lengthwise into two pieces, one longer than the other and having a butt at one end. The two pieces had each the same number of notches and each bore the date of the deposit and the name of the depositor. The smaller piece was given to the depositor as a certificate of the deposit; the larger piece was retained in the Exchequer as a record of the transaction. If a piece of paper is torn in two we have two pieces that match when brought together, but no other piece can ever be torn to match either of the first two. And so with the tally sticks. No other stick could ever be split to match either the one held by the depositor or the one in the Exchequer. Counterfeiting was impossible.

"When the depositor wanted his money, he presented the stick at the Exchequer, the corresponding piece was found, the two were fitted together, and the amount indicated by the notches was paid by the Exchequer. This system was in force for a thousand years or more previous to 1826, when the last payment on a tally stick of which there is any record, was made. During that long period a large amount of money accumulated in the Exchequer in the form of unclaimed deposits, which were represented by a large number of these wooden tally sticks. Even in modern times large amounts of money accumulate in the banks in the form of unclaimed deposits. Naturally the failure of depositors to claim their money during the middle ages would be more frequent than under the more peaceful conditions of modern times. Many of the depositors in the British Exchequer were Jews, who for centuries suffered persecution in England as cruel as any suffered by that race in Russia in recent years. It is believed that a large part of the unclaimed deposits in the British Exchequer belonged to Jews, who had lost their property, many of them their lives, in the persecutions during the dark ages.

With the adoption of written records the tally stick system, which had been used so long, became obsolete, and the British Exchequer found itself in 1834 encumbered with several cords of these sticks, the evidence of debts, large and small to unnumbered generations of gentiles and Jews. In that year the officials of the Exchequer decided that the old sticks should be destroyed, and an order was issued to that effect. It was at first proposed to make a big bonfire with them in the open yard connected with the Parliament Houses. Finally, however, it was decided to burn them in the furnace in the basement of the House of Lords. They were brought from the Exchequer to the basement on Wednesday, Oct. 15, 1834, and early the next morning two or three men began this unusual task.

"A pile of little notched sticks bearing strange looking inscriptions in abbreviated Latin and old English script, the evidence of thrift for a thousand years, tokens of all the motives that prompt men and women to save. Love and hate, greed and sacrifice, hope and fear, frugality and fraud, the proceeds of honest toil and of crime, held for ages that the missing pieces carried away by successive generations might be redeemed, their presence a mute evidence of the blasted hopes of depositors for a thousand years. They were fed steadily to the flames from early morning until a few minutes before seven o'clock in the evening of Thursday, Oct. 16, 1834, when suddenly a furnace flue, overheated by the unusual fire, started a blaze in a room above, and in a few hours the House of Lords and the House of Commons were in ashes, along with nearly all the old wooden tally sticks and all the basic standards of weight and measure for the British Empire. The Houses of Parliament have been rebuilt. The standards of weight and measure were reproduced from the countless standards scattered throughout the world and which make their loss impossible except by a cataclysm that would destroy the world itself. But a few of the old tallies were saved. These were carried to the standards office, where they remained until a few years ago. I am the possessor of one of these, which you see here. It is for £3, 6s, 8d and bears this inscription: "Deposit by Thos. de Lovetot in the 20th year of Edward III" (1347), five hundred and sixty-one years ago and one hundred and forty-five years before the discovery of America. I shall be glad to redeem the missing part of this tally at its face value. My payment of the interest on this deposit is quite out of the question, for I find that with interest at 6 per cent compounded yearly the amount due in 1908 would be over eleven hundred million millions of dollars, equal to the value of a globe of solid gold over one-third of a mile in diameter."

The production of beryl gems, as aquamarine, blue beryl, golden beryl, rose or pink beryl and white beryl, was chiefly from California, North Carolina, Colorado, and Maine, with small amounts from New Hampshire, Pennsylvania, and Connecticut.

FOG ON THE NEWFOUNDLAND BANKS.

By C. T. Brodrick.

During the greater part of the year the route for high-powered steamers between Nantucket Lightship and Fastnet or the Scilly Islands crosses the forty-seventh meridian to the south of latitude 43° north, making a considerably greater distance to be traversed by thus avoiding the Grand Banks. This circuitous route is taken because of the fog and the ice found in this district during the spring and summer months. Numerous collisions with other vessels and with icebergs occur every year, and some accidents in the past have been accompanied by large loss of life.

The occurrence of fog about the coasts of Newfoundland and farther north was noted by some of the earliest explorers of the regions—Cook, Ross, Parry, and others. They remarked on its density, that it did not extend to any great height above the water, and that it was most prevalent with southerly winds. Some interesting speculations on the causes of these fogs are set forth at considerable length in Henry Ellis's "Voyage to Hudson's Bay," (1748). His fantastic theories are in strange contrast with our present ideas, even with his own considerable accuracy of observation.

In 1822 Scoresby published some data which he had accumulated during the previous summer. His general conclusions were that fogs are more prevalent during the summer months, that they have an average thickness of from 150 to 250 feet, and that they are accompanied by inversions of temperature. He thought they were caused by the chilling of warm, damp air through contact with the ice.

With the exception of a few scattered articles which added nothing new, little was written on these subjects down to 1875. In 1877 an article by Neumann gave an excellent summary of the facts known at that time and the theories as to the causes of the fog. He noted particularly the effect of the proximity of the Gulf Stream and the Labrador current, the vast amount of floating ice, and the prevailing winds, and he also suggested that the temperature of the water should be the best warning to vessels in a fog of the proximity of ice fields or bergs.

During the next ten years considerable interest was taken in the subject, and several papers were printed. The work of two men deserves special notice. In a series of articles in the *Monthly Weather Review*, Prof. E. B. Garriott outlined the conditions governing the prevalence of fog in relation to the passage of cyclones and anticyclones north of latitude 35° north, and suggested the feasibility of predicting fog and issuing forecasts for outgoing steamers.

Two years later, in 1889, J. P. Finley published a "Sailor's Handbook," in which he quoted from Professor Garriott's work, adding a series of charts showing the average and extreme limits of fog areas, based on data accumulated during the previous 32 months.

By far the most complete discussion of the subject is an article by Dr. Gerhard Schott, entitled "Die Nebel der Neufundland Banke."

With the addition of an article in the Annalen for 1904 on the relation of fog to wind, it expresses completely the present views, which may be briefly summarized as follows:

These fogs occur roughly over the area inclosed on the maps by the 200-fathom line, forming two centers of maximum frequency, one over the Grand Banks, southeast of Newfoundland, the other east of Massachusetts Bay. Over the greater part of this district, from May to August, more than 60 per cent of the total number of hours of observation are foggy. The minimum occurs in February. Southerly to westerly winds of a force 3 or 4 on the Beaufort scale are the most favorable to fog formation. Warm air from over the ocean, heavily charged with moisture, is thus brought in contact, within a distance of less than 300 miles, with colder water at a temperature of 30° F., and the formation of fog results. These conditions occur in the southeastern quadrant of a cyclone which leaves the States north of latitude 40° north. After the passage of the low area northwest winds follow, and these are accompanied by clearing weather. During the winter the close succession of cyclonic and anticyclonic areas prevents the long-continued fogs characteristic of the stagnant atmospheric conditions of the summer. Moreover, the prevailing winds during the summer are from a southerly quadrant, while those of the winter are from the northwest.

The importance of collecting data on these fogs and charting them, has been recognized by most of the nations whose shipping is affected. Pilot charts on which the occurrence of fog is shown are published monthly by Germany, Great Britain, and the United States.—*Monthly Weather Review.*

MISSOURI BOTANICAL GARDENS.

The nineteenth annual report of the Missouri Botanical Gardens that has just been received contains, in addition to the report of the financial condition of the gardens, five scientific papers. Two of these are of such a nature as to be especially interesting to teachers of botany in secondary schools. One of these, "The Florida Strangling Figs," by Ernst A. Bessey, gives by text discussion and abundant photographs an excellent presentation of the ways in which these peculiar trees begin their growth upon other trees, as oaks and palms, and how, by sending roots to the ground and branches around the supporting tree, the fig tree eventually entirely surrounds it.

The article by Henri Hus upon "An Ecological Cross-section of the Missouri River in the Region of St. Louis, Missouri," is full of interest since it applies to this region in its various plant formations the methods of ecological study that usually have been applied to regions of less variation than here presented. In addition to the general interest and importance of this paper, in the immediate vicinity of St. Louis it should prove a great source of stimulus and help.

Other papers of botanical value are "Crataegus in Missouri," by C. S. Sargent, "Illustrated Studies in the Genus Opuntia," by David Griffiths, and further contributions upon the Agaves by William Trelease.

O. W. C.

ARTICLES IN CURRENT MAGAZINES.

American Naturalist: "Further Studies on the Activities of Araneads," Thos. H. Montgomery, Jr.; "Notes on the Daily Life and Food of Chambarus Bartonius Bartoni," Floyd E. Chidester; "Some Points in the Ecology of Recent Crinoids," A. H. Clark.

Astrophysical Journal, November, 1908: "The Distribution of Eruptive Prominences of the Solar Disc." Philip Fox; "Effect of Increasing the Slit-Width upon the Accuracy of Radial Velocity Determinations," J. S. Plaskett; "The Spectroscopic Binary 4 Orionis," J. S. Plaskett; "The Orbit of i Orionis," J. S. Plaskett; "Photographic Light-Curve of the Variable Star, Su Cassiopeiæ," J. A. Parkhurst; "The Reproduction of Prismatic Spectrum Photographs on a Uniform Scale of Wave Lengths," A. Fowler and A. Eagle; "Comet c 1908," (Morehouse), E. E. Barnard; "An Electric Furnace for Spectroscopic Investigations, with Results for the Spectra of Titanium and Vanadium," Arthur S. King; "On the Probable Existence of a Magnetic Field in Sun Spots," George E. Hale.

Economic Geology for October-November: "The Shale Oil Industry of Scotland," D. R. Stewart; "Origins of the Cobalt-Silver Ores of Northern Ontario," R. E. Hore; "A Genetic Classification of Minerals," William H. Emmens.

Journal of Geology, for October-November: "Structural Geology of the Middle Yang-tse-kiang Gorges," E. C. Abendanon; "Recent Studies in the Grenville Series of Eastern North America," Frank D. Adams; "A Study of Damage to Ridges During Earthquakes," Wm. H. Hobbs.

Physical Review, for November: "Equilibria in Standard Cells," G. A. Hulett; "Studies in Luminescence. X. The Phenomena of Phosphorescence Considered from the Standpoint of the Dissociation Theory." Edward L. Nichols and Ernest Merritt; "On the Charges Gained by Insulated Metallic Conductors Surrounded by Other Conductors and the Relation of These Charges to the Volta Effect," J. K. Robertson; "An Investigation of the Electric Intensities and Electric Displacement Produced in Insulators by Their Motion in a Magnetic Field," S. J. Barnett.

Popular Astronomy, for December: "Photographic Observations of a Very Remarkable Comet," E. E. Barnard; "On an Infinite Universe," W. H. S. Monck; "Rigidity of the Earth," T. J. J. Lee; "An Astronomical Theory of the Molecule and an Electron Theory of Matter," S. J. Corrigan; "The Northern Limit of the Zodiacal Light," E. A. Fath.

Popular Science Monthly for December: "The Cause of Pulsation," Dr. Alfred Goldsborough Mayer; "A Biographical History of Botany at St. Louis, Missouri," Dr. Perley Spaulding; "The Application of Zoölogical Laws to Man," William Ridgway; "Canadian Wheat," John Waddell; "College Standardization," W. Le Conte Stevens; "Aspects of Modern Biology," T. D. A. Cockerell; "Loyalty," John C. Branner; "The Story of Professor Röntgen's Discovery," Elmer Ellsworth Burns; "A Great Permian Delta and its Vertebrate Life, with Restorations by the Author," Dr. E. C. Case.

School Review for November: "Elective Subjects in the High-School Curriculum," W. C. Bagley; "Fourth Report on the College Entrance Course in Botany," W. F. Ganong, F. E. Lloyd, and H. C. Cowles, Committee; "The Corporate Life of School, II," J. J. Findlay; "The Study of Education in the High School," Raymond W. Seis.

School World, London, England, for November: "The Qualification of the Teacher of Geography," Ernest Young; "A Simple Course of Practical Physics," W. H. Salmon; "Elementary Science in the Primary School," J. W. Shuker; "On the Use of Vulgar Fractions and Decimals," F. R. Robinson.

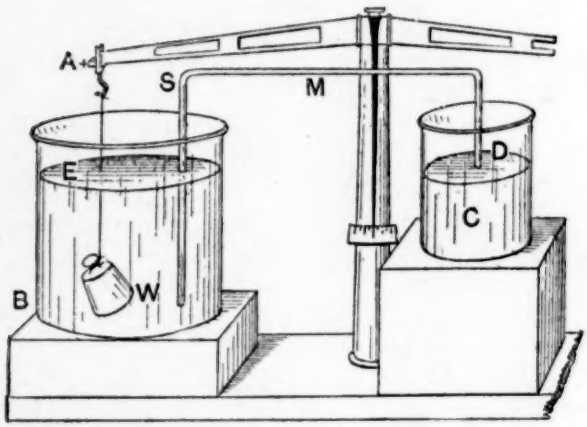
Scientific American Supplement for November 7: "Electrolysis and Corrosion," A. S. Cushman; "Longitudinal Stability of Aeroplanes," H. T. Strong; "Markings and Colors in Fish," Francis Ward; "Forcing Plants by Warm Baths," Hans Molisch; "Solar Eclipses and Ancient History," Samuel Jennings. For November 21: "Marvels of a Plant's Growth," Vivian B. Lewes. For November 28: "Can Precious Stones be Manufactured?" Stanley C. Bailey; "The Passing of the Whale," Frederic A. Lucas. For December 5: "Low Temperature," Sidney F. Walker; "Radium in Rocks and in the Ocean," John Joly; "Casting Pipes in Permanent Molds," Edgar A. Custer; "The Skin Moult of a Caterpillar," William Farben; "Recent Astronomical Research," C. G. Abbott.

METHOD OF ILLUSTRATING THE PRINCIPLES OF ARCHIMEDES.

By W. Crabb, Whitgift Middle School, Croydon.

Bend a piece of glass tubing twice at right angles, S. On a specific gravity table place a beaker, B, containing the liquid to be experimented with. Place S as shown, held tightly by a retort clamp at M. Suck at the end of the shorter limb, D; the liquid siphons over until the level of the surface E is the same as that of the end of D.

Weigh a beaker, C (it simplifies matters for the smaller boys if C be taken clean and dry, the liquid which siphoned over at first being collected in some other vessel). Place C under D.



From the left-hand arm of a balance, A, hang any sort of solid of convenient size which is insoluble in the given liquid. It saves one weighing to use a hundred-gram weight. Completely immerse this solid, W, in the liquid in B in such a way that it does not touch the sides of B. Find the loss of weight of W, and also the weight of liquid which siphons over into C. These weights will be equal. Of course, no part of W must come above the level of the surface E during the experiment. Repeat the experiment, using various liquids. Then repeat, using a solid lighter than the liquid; the apparent weight of the solid in the liquid will be nothing.

In carrying out this experiment before a class use a large balance, and send one of the pupils to a smaller balance to do the weighings of C. By fastening the siphon to the beaker with a clip matters are simplified, and the pupils themselves can do the whole series of experiments in a very short time. This is still more the case if we use the simple volumenometer sold by Messrs. Griffin and Sons, Ltd., and other makers, for about eighteenpence.—*School World.*

MEETING OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Eighth Meeting of the Central Association of Science and Mathematics Teachers was held, Nov. 27-28, 1908, at the Englewood High School, Chicago.

This meeting, in the interest displayed by those in attendance, in the value of the various programs presented, and in the character of the constructive work accomplished, was the most successful ever held by the association.

The attendance was nearly 400. Twelve states were represented, an indication that the sphere of influence of the association is widening as its work becomes better established and better known.

The address of Professor Robert K. Duncan of the University of Kansas, upon "Modern Chemistry and Industry," at the general meeting on Friday, Nov. 27, was brilliant and forceful and, in the estimation of many, the finest to which the association has ever listened. The address by Professor D. O. Barto of the University of Illinois upon "Problems in Secondary School Agriculture," was helpful and timely.

The section meetings will be given more extended notice in separate reports to be published in SCHOOL SCIENCE AND MATHEMATICS. The work of each section was progressive and constructive. It was characterized by reports upon the fundamental principles and topics to be considered in Mathematics, Biology, Earth Science, Chemistry, and Physics. Many of these are of permanent value and will be found elsewhere.

Friday evening a dinner, attended by 140 members, was held at the Englewood Baptist Church. Following this was an address by Superintendent W. H. Elson of Cleveland, Ohio, on "Practical Education." After this address the Physics Section program planned for Saturday morning was given. This arrangement accommodated a number of college men who wished to attend the meeting of the American Physical Society at Northwestern University on Saturday.

At the meeting Saturday morning much business of interest and importance to the Association was accomplished. The first of this was the election of officers.

The new officers of the Association are: President, James H. Smith, Austin High School, Chicago; Sec.-Treas., Willis E. Tower, Englewood High School, Chicago; Asst. Sec.-Treas., Frank E. Goodell, North High School, Des Moines, Iowa.

The section chairmen follow: Biology, T. W. Galloway, James Millikin University, Decatur, Ill.; Chemistry, G. A. Abbott, Manual Training High School, Indianapolis, Ind.; Earth Science, Marion Weller, Northern Illinois State Normal School, De Kalb, Ill.; Mathematics, Chas. Ammerman, McKinley High School, St. Louis, Mo.; Physics, Chas. H. Perrine, Wendell Phillips High School, Chicago.

The proposed amendments reducing the annual dues to two dollars and making associate membership dues one dollar, were defeated.

This action was taken as the Executive Committee is to publish a report of the annual meeting in the near future, including other material of interest to members of the association and plans to issue other bulletins and reports during the year. These reports will make the association much more helpful to those of its membership who are unable to attend its meetings, beside preserving in convenient form available to anyone the record of the work of the association. The additional expense in issuing these reports made it necessary to maintain the dues at $2.50.

A committee consisting of F. T. Jones of Cleveland, J. H. Smith and O. W. Caldwell of Chicago, was appointed to coöperate with committees from other Associations of Science and Mathematics teachers in our territory in order that through coöperation and coördination of the work of these associations there may be little overlapping of effort and greater efficiency than is possible otherwise through the actions of individual associations.

The committee on resolutions reported as follows: Be it resolved (1) That we express our appreciation and lasting obligation to the Englewood High School, including Principal Armstrong, his teachers of science and mathematics, and his high school pupils for the appropriate arrangements that they have made for this meeting.

(2) That our secretary be instructed to express in writing to Professors Duncan and Barto and to Principal Armstrong and Superintendent Elson an appreciation of their services.

(3) That arrangements be made upon the general program for presentation of brief summaries of definitions of the purpose and scope or so-called fundamentals of separate subjects as determined by the separate sections of the association. This in no sense involves supervision or censorship by the whole association, but is designed to keep all members informed upon constructive work that is going on within its sections.

(4) That we believe in the recognition and inclusion within our courses of the practical and applied aspects that make possible an appreciable significance and belief in the worthwhileness in practical life of the various subjects studied.

(5) That we believe that formulation of secondary school courses should be made entirely from the point of view of the needs of the majority of secondary school pupils, and further that any course that is best for the majority of secondary school pupils is the best for college entrance.

(6) That we recommend to the Executive Committee the publication of a bulletin giving the proceedings of the annual meeting as early as practicable after the meeting.

Another resolution was presented and adopted: *Whereas*, This Association several years ago advised the various State Teachers' Associations to consider and recommend reasonable changes in the statutes governing the teaching of physiology and hygiene with reference to the effects of alcohol and narcotics, and,

Whereas, The State Teachers' Association of Illinois has prepared a bill to present to the legislature at its next session, which places the emphasis upon hygiene and morals and economics rather than upon supposed scientific principles and places the whole matter of method in the hands of the teaching profession where it belongs. Therefore be it,

Resolved, That we heartily endorse the action of the Illinois State Teachers' Association in their effort to put the teaching of temperance physiology and hygiene on a true pedagogical basis.

The association formally joined the American Federation of Teachers of Mathematics and the Natural Sciences and selected eight delegates to represent the Central Association. Invitations were extended to the Association by representatives from Des Moines, Iowa, Cleveland, Ohio, the University of Chicago, and Lewis Institute, Chicago, to hold the next meeting at their respective locations. The matter was referred to the Executive Committee.

W. E. TOWER, *Secretary.*

REPORT OF THE MEETING OF THE MATHEMATICS SECTION OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, CHICAGO, NOVEMBER 27-28, 1908.

The section held two sessions, one Friday afternoon and one Saturday morning. The session Friday afternoon was devoted to the discussion of the report of the Committee on Unification of Mathematics in the Secondary Schools and to the discussion of the third report of the Committee on Geometry. The session Saturday morning was devoted to the further discussion of the report of the Committee on Algebra, which was presented one year ago.

The chairman, Mr. J. C. Stone of Ypsilanti, Mich., presided. The following business was transacted:

The chairman stated that the section was asked to appoint one member to meet with a committee of ten at Baltimore, Md., December 28, to draw up a national syllabus on plane geometry. It was decided that the chair should appoint a committee of three to make the selection. The chair appointed Mr. J. V. Collins, Mr. H. E. Cobb, and Mr. Chas. Ammerman.

It was decided that the Committee on Unification of Secondary Mathematics be retained for another year.

It was decided that a committee be appointed to study the possibility of gathering together from the original sources the real applications of algebra and geometry for class room use.

It was decided that the Committee on Algebra be retained and that they be asked to prepare the report for re-publication.

The following officers were elected for the next year. Mr. Charles Ammerman, McKinley High School, St. Louis, Mo., Chairman; Mr. C. A. Pettersen, Jefferson High School, Chicago, Ill., Vice-Chairman; Miss Mabel Sykes, South Chicago High School, Chicago, Ill., Secretary.

Report On the Unification of Secondary Mathematics.

The report of the Committee on Unification of Secondary Mathematics was presented by Mr. H. E. Cobb of Lewis Institute, Chicago, chairman of the committee. Mr. Cobb called attention to the paragraph on squared paper, to the curriculum of the Oberrealschule, Schöneberg bei Berlin, to the world-wide nature of the movement under discussion, to the list of books given in the report, to the introduction of problems as the chief means of bringing about unification, to the preliminary outline for work in mathematics in secondary schools.

Mr. S. C. Davisson, University of Indiana: Problems should be made more practical. Pupils should be carefully trained in translation from mathematical language into English and from English into mathematics. Pupils at University of Indiana are more poorly prepared in mathematics than formerly. This is partly due to the congestion of the curriculum. Pupils should learn to do a few things and do those few well.

Mr. G. W. Myers, School of Education, University of Chicago: It is necessary to get the point of view of the pupil, not that of the mathematical expert. We will never get efficiency until the pupil feels himself efficient in something in which he is interested and thinks worth while. Boys and girls have more interests in touch with geometry than with algebra. The introduction of geometry problems into algebra gives interest to the algebra. Unification opens up mathematics from the point of view of the pupil.

Mr. F. W. Millis, Francis W. Parker School, Chicago: The different subjects in secondary mathematics should be kept distinct, and one subject taught at a time. The subjects should be made more practical; their actual applications in the real problems encountered in the world's work should be made points of departure in teaching the subjects and their applications in school. The unification of the different subjects will be preserved in the use of these problems and in drill exercises whose data are based upon relations known from other subjects.

Miss Edith Long, Lincoln, Neb.: Unification is practiced in the high school at Lincoln. No mathematics is now given in the ninth grade; a course in general science is given instead. In the tenth grade the mathematics includes algebra and demonstrative geometry and the division is made by subjects. The four fundamental processes of algebra are first taught. These are followed by equations and problems, supplementary angles, congruent triangles, and proofs of easy originals in geometry. This is followed by other subjects of algebra and geometry. Formerly this course was begun in the second semester of ninth grade and worked well there.

Mr. W. W. Hart, Indianapolis, Ind.: Fusion is feasible. It has been used and is being used. Every one is recommended to try it.

The fact mentioned by Mr. Davisson that pupils entering universities are more poorly prepared in mathematics than formerly, received attention in the discussion. This leads to the question should we teach algebra and geometry in the last two years of our high schools for the most part, and teach it from the scholastic point of view, or

should we begin it in the ninth grade and teach it from the point of view of the child. The following persons expressed an opinion on this point: Mr. Wines, Ann Arbor, Mich., Mr. R. L. Short, Cleveland, O., Mr. L. P. Jocelyn, Ann Arbor, Mich., Mr. C. E. Comstock, Peoria, Ill., and others.

Third Report of the Committee On Geometry.

The third report of the Committee on Geometry was presented by Mr. G. W. Greenwood, Dunbar, Pa., chairman of the committee. The report is along the same lines as the original report and deals with solid geometry.

Miss Mabel Sykes, Chicago, Ill.: The chief service rendered by the report is in calling attention to the fact that geometry as taught in our schools is not the beautifully logical structure that we once supposed. This service is an important one and well rendered. The report is deficient in that it does not show how to make geometry contribute to larger life. To this end we need practical problems. Most teachers do not know where to find such problems, and the report renders very little assistance. We need also to know the important general principles and theorems about which to group details. Geometry is not one dead level of monotony. The report should have distinguished between the least and the most important theorems.

Mr. Coultrap, Naperville, Ill.: Correlation by general principles is the best kind. General principles should be taught; they unify details.

Mr. D. S. Wright, Cedar Falls, Iowa: The wisdom of eliminating the incommensurable cases should be emphasized. The study of the infinitesimal has no place in elementary geometry.

Mr. J. F. Millis, Chicago, Ill.: General principles and important theorems are well brought out by means of practical problems. It is surprising how few general principles there are that are of frequent occurrence in such problems.

Mr. J. V. Collins, Stevens Point, Wis.: Algebraic analysis is very useful in geometry problems. Many numerical calculations should be introduced.

Mr. J. F. Millis, Chicago, Ill.: Many practical problems requiring construction or proof are found in forestry, architecture, building trades, navigation, manual training, and so on. These must be obtained from the original sources; they are not in books.

Mr. G. B. Halsted, Greeley, Colo.: In looking for practical problems decoration, logic and graphic statics must not be omitted.

The Report of the Algebra Committee.

The report of the Algebra Committee with corrections and additions was presented by Mr. Chas. Ammerman of St. Louis, Mo., chairman of the committee. He called attention to the main features of the report, the arrangement of the work into a first-year course and a later course, the main purpose of first-year work which should be the solution of problems by means of equations, the omission of certain topics from first year work, a change in the order of topics to suit

this purpose. The classification of problems according to subject matter, and a simpler and more pedagogical treatment of radicals in first-year work.

Mr. G. B. Halsted, Greeley, Colo.: The child has no experience out of which to draw mathematics. Intuition and instinct precede experience, and hypothesis precedes experiment. The hypotheses must be given to the child by the teacher. It is impossible to draw them out by so-called development lessons. The form $2^{\frac{1}{2}}$ is recommended instead of $\sqrt{2}$.

Mr. W. H. Williams, Platteville, Wis.: The main purpose of first-year work as given in the report makes problems too prominent. Problems should be so chosen that general principles can be developed from them. Skill in manipulation must not be overlooked in first year. Many details in the report are admirable.

Mr. L. P. Jocelyn, Ann Arbor, Mich.: The subject should not be brought down to the level of first year pupils. Algebra and geometry should be taught later in the high school course.

MABEL SYKES, *Secretary.*

There are no copies of the algebra report or of the geometry report for distribution at present, but it is hoped that each may be reprinted. The report on unification was printed in SCHOOL SCIENCE AND MATHEMATICS for November and December. A few reprints are available for distribution. Send a two-cent stamp to Secretary, Miss Mabel Sykes, 438 E. 57th St., Chicago, Ill.

BIOLOGY SECTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The Section was called to order by the chairman, Fred L. Charles of the state normal school at De Kalb, Ill. A nominating committee consisting of I. N. Mitchell, Milwaukee, T. L. Hankinson of Charleston, Ill., and Miss M. F. McAuley, St. Charles.

Mr. I. N. Mitchell read a paper on "Field Work on Trees." He emphasized the value of tree knowledge and importance of some simple and non-technical key to enable pupils to become familiar with ordinary trees. Such a key was shown by the speaker. The discussion was participated in by A. H. Conrad of the Crane High School, Chicago, W. N. Clute of the Joliet High School, and W. W. Whitney, South Chicago High School. Mr. Whitney advocated plotting an area and furnishing pupils a chart of the trees. Dr. Otis W. Caldwell of the University of Chicago urged the advisability of more intimate knowledge of the ecological associations of trees. Mr. Charles advocated a frank naming of the tree showing silhouette, branches, bark, character of buds and twigs, duration of leaves and fruit. Dr. Cowles of the University of Chicago recognized the inevitable demand on the part of the pupil for the name to be followed by a study of the characteristics. General discussion.

In the absence of Sec'y Lynds Jones, his paper on "Field Work on Birds" was read by John E. Cameron of Kansas City. The general discussion was participated in by Messrs. Cameron, Whitney, Clute, Myers, and Miss Smallwood. Chairman Charles advocated the taking of a bird census and caused intense interest by recounting an intensive study of a nest of robins in the museum window.

Dr. H. C. Cowles read his paper on "Field Work on Common Weeds." The paper bristled with suggestions as to weeds and weed study. How weeds manage to succeed, seed dispersal, annuals against perennials, struggle for existence, weed plot study, competition among seedlings, etc. General discussion led by Mr. A. H. Conrad. He said that weed study was rich in content and interest for the pupil and suggested that pupils make weed and seed collections.

Professor Barton of the University of Illinois called attention to the fact that weed study was an integral and important part of the work of the School of Agriculture.

Mr. T. L. Hankinson, State Normal School, Charleston, Ill., read the next paper on "Field Work on Fishes." He showed how desirable and valuable work on fishes may become, the correlation of fishes with other phases of biology. Discussed by Mr. Large of Oak Park, Ill.

The paper on "Field Work on Insects" was omitted owing to the absence of the author, J. W. Folsom, University of Illinois. A general discussion on the paper was held led by F. C. Lucas of the Englewood High School, Chicago, who called attention to a simple key for insect identification. Mr. Whitney exhibited a series of insect cases showing the manner of mounting and method of construction. Miss Chapman of University of Chicago described results obtained by using observation (glass) hives for bees, arousing intense interest in pupils. Dr. Betten of Lake Forest University and Dr. Galloway of James Millikan University, Decatur, Ill., both commented on the adaptability of insects as valuable teachable material. Mr. Wright of the McKinley High School, Chicago, by request, spoke of the pleasing work to be done with spiders. Adjourned to see the colored photographs and lantern slides brought by the chairman of section.

The Saturday morning session was called to order by Chairman Charles.

Report of Nominating Committee was received, and on motion the secretary ordered to cast ballot for the following officers for the ensuing year: Chairman, T. W. Galloway, James Millikan University, Decatur, Ill.; Vice-Chairman, Amelia McMinn, West Division High School, Milwaukee, Wis.; Secretary, Mabel E. Smallwood, Lane Technical High School, Chicago. Upon motion of Dr. Galloway, the chair appointed a committee of five to continue the work on "formulation of fundamental principles.

Report of Committee on Formulation of Principles presented by Drs. Galloway and Caldwell.

General discussion.

Mr. Mitchell, Hyde Park, Chicago, commented on the qualifications of teachers of biology and the effect of biology on sociology and related sciences.

Mr. Meyers, University of Chicago, emphasized the fundamental principle of the child being the center of interest and the importance of the correlation of the grades and high school in their contact with the pupils.

Mr. Lucas spoke of the advisability of segregation in High School and its results in the Englewood school.

Dr. Garber, St. Louis, advocated following the experience of the pupil in nature work and thereby the path of most intense interest in the child's mind.

A forecast by the Chairman-Elect, Dr. Galloway, that the year show results in concerted action by the members on various phases of field work.

Moved and carried: Report of the Committee on Formulation of Principles be approved and accepted. Meeting adjourned.

C. L. HOLTZMAN, *Sec. Pro-tem.*

SOUTH DAKOTA ASSOCIATION.

The South Dakota Association of Science and Mathematics Teachers held its second annual meeting at Huron, S. D., Nov. 21, 1908.

The program was as follows:

Music: The Huron High School Glee Club.

Address by the President of the Association.

Paper, "Mistakes in Geography Teaching," Willis E. Johnson, Aberdeen, S. D.

Paper, "The Relative Values of Botany and Zoology in the High School," L. S. Krake, Yankton, S. D.

Informal Discussion, "On the Value of High School Algebra," Dr. T. E. McKinney, Vermillion, S. D.; Clyde Slone, Huron, S. D.

Paper, "Physiology and Elementary Science," Mary E. Perkins, Sioux Falls, S. D.

Paper, "Modern Problems in Biology," Dr. R. C. Mullenix, Yankton, S. D.

The Association decided to hold a meeting at Aberdeen, Tuesday afternoon, Dec. 29 from 5 to 7:30, during the sessions of the State Educational Association.

The Association adopted the Articles of Federation of the American Federation of Teachers of Mathematical and Natural Science.

L. E. Akeley of Vermillion was elected delegate to the Council.

The officers of the Association were reëlected as follows:

President, L. E. Akeley, Vermillion, S. D.

Vice President, Fred W. Smith, Aberdeen, S. D.

Secretary-Treasurer, L. W. Beers, Sioux Falls, S. D.

Benitoite is a new gem mineral from California from the Mt. Diablo range, near the San Benito-Fresno county line. The gem has a blue color and was first mistaken for sapphire when discovered early in 1906 by Messrs. Hawkins and Sanders.

BOOKS RECEIVED.

Foundations of Mathematics, a Contribution to the Philosophy of Geometry, by Paul Carus. iv+141 pages. The Open Court Publishing Company, Chicago.

A First Book in Phonics, by Florence Akin, Lane School, Roseburg, Oregon. 64 pages. Atkinson, Mentzer and Grover, Chicago.

Practical Mathematics, by G. A. Consterdine and A. Barnes. 332 pages. 1908. Price, 2s. 6d. John Murray, Albemarle St., London.

Practical Arithmetic, by G. A. Consterdine and S. O. Andrew. 228 pages. 1908. Price, 2s. John Murray, Albemarle St., London.

Examples in Practical Arithmetic, by G. A. Consterdine and S. O. Andrew. Parts I and II. 122 pages each. 1908. Price, 6d. each. John Murray, Albemarle St., London.

A First Course in Algebra, by Webster Wells. 240 pages. 1908. Price, $1.00. D. C. Heath and Company, Chicago.

Training the Teacher, by A. F. Schauffler, D.D., and others. 270 pages. 1908. Price, 50c. Sunday School Times Co., Philadelphia.

Analytic Geometry, by E. W. Nichols. Revised Edition. 282 pages. 1908. Price, $1.25. D. C. Heath and Company, Chicago.

BOOK REVIEWS.

A little pamphlet of 19 pages entitled *A First Lesson in Differential Calculus*, by Charles N. Schmall, B.A., and published by the author at 89 Columbia St., New York, contains some suggestions as to practical means of handling the very beginnings of differential calculus with pupils that are none too clear as to the meanings of the notions of elementary mathematics. The pamphlet is worth the time it would take for a teacher of the subject to glance it over. G. W. M.

A First Book in Phonics, by Florence Akin, Lane School, Roseburg, Oregon. 64 pages. Atkinson, Mentzer and Grover, Chicago.

This little book will be exceedingly helpful to the primary teacher, in assisting her to instruct the child in phonics. Each sound is represented as being made by pronouncing the name of some object with which the child is familiar.

The words used in the book are simple and largely those which the child has used in his first reading lessons. Each little story is illustrated by a picture which will appeal to the child, thus securing at once his attention.

The mechanical make up of this book is superb, type large and clear, the arrangement of matter excellent, and the binding is without fault.

C. H. S.

Inductive Geometry, by Col. C. W. Fowler, Superintendent of the Kentucky Military Institute, and Professor of Mathematics, Lyndon, Ky. Pp. 52. Third edition. 1905. Published by the author.

This book was written to prepare the way for the intelligent study of geometry. It consists of 354 exercises well selected and logically arranged. It gives the pupil the concepts of geometry which he should

have before he is required to demonstrate propositions, and enables him to construct accurately the figures about which he reasons. The use of this book, or a similar one, in connection with the first year algebra, or for the first few weeks of the year given to geometry, would doubtless tend to stop the unfortunate practice of requiring pupils to describe operations which they have not tried to perform and possibly could not perform. H. E. C.

Two important extracts from the *Scientific Annales of l'Ecole Normale Superieure*, from the press of Gauthier-Villars, Paris, have recently appeared on the mathematical editor's table. The first is a most interesting and profound mathematical study of the *Equations of Elasticity*, by M. A. Korn, covering 75 large quarto pages. As a resume and a restatement of the work heretofore done, of methods hitherto developed in the theory of elasticity, this pamphlet is of high value.

The second extract is from the same *Annales*, the same press, and by the same author. It treats of the mechanical theory of gravitation, of attraction within continuous masses, and of some electrical considerations. The larger title of the paper is *The Universal Vibrations of Matter*. The pamphlet of 20 pages is a lucid mathematical study of some rather profound questions suggested by the title. It is interesting and profitable reading to advanced workers in this field. G. W. M.

Progressive Problems in Physics, by Fred R. Miller, Boston English High School. 1908. Price, 60c. D. C. Heath and Company, Boston.

Here it is, the book of problems that every physics teacher has been looking for. It contains 189 pages of well selected and graded problems on every topic treated in elementary physics. There are also 23 pages of entrance examination questions to Massachusetts Institute of Technology, Harvard and Yale, Sheffield Scientific School; three pages of tables and physical constants and two pages of four place logarithms.

The book is written by a teacher of many years' experience in one of the largest high schools of this country, assisted by other experienced teachers.

There is a great need for such a book because our recent text-books in physics are so weak on problems, there being uniformly too few in number, poorly selected, or else beyond the capacity of the average city high school pupil of the third year. C. M. T.

Laboratory Manual of Qualitative Analysis, by Wilhelm Segerblom, A.B., instructor in chemistry at the Phillips Exeter Academy. Longmans, Green & Co. 1908. xiii+136 pp. Price, $1.25.

This manual, in the words of its author, is a statement of the method that has worked well with the classes at the Phillips Exeter Academy. The various group separations and individual tests are the usual ones, the results to be looked for are clearly indicated. After describing the separations and tests for each group a complete list of the equations, for all the reactions involved is given, these would be of more use to the student if he worked them out for himself.

While the directions are given clearly and with enough detail to lead to the separation and identification of the various elements, very little attention is given to theoretical considerations, such as the laws of equilibrium, and theories of solutions. The book contains a good list of books for collateral reading, with brief comments on their special features. It has a carefully prepared index. A. L. S.

Education by Plays and Games, by George Ellsworth Johnson, Superintendent of Playgrounds and Vacation Schools, Pittsburg, Pa. xiv +234 pages, 131 illustrations. Ginn and Company, Boston and Chicago.

To those who have the pleasure of amusing and keeping interested groups of children, this book will be of especial interest. It is primarily intended to retain the interest of the child while he is at work, to cause him to be amused while in the act of doing something other than mere play. In adopting or electing that game for the child, the thought of the book is, choose that one which will psychologically fit into his condition or state of mind at the time.

To those who wish to entertain a company of children for an afternoon or at a picnic, the book will offer many suggestions.

Not the least important feature of the book is the splendid array of illustrations, most of them being photographs of children while in the act of carrying out some particular game or play.

A bibliography of six pages is given. The index is complete, covering six pages. The mechanical work on the book is of a high order, thus enabling it to stand hard usage. Clear ten-point type is used and the matter is well arranged. C. H. S.

A Text-book of Organic Chemistry, by A. F. Holleman, Ph.D., F.R.A., Professor Ordinarius in the University of Amsterdam. Translated from the Third Dutch Edition by A. J. Walker, PhD., assisted by Owen E. Mott, PhD., with the coöperation of the author. Second English Edition Rewritten. John Wiley & Sons. 1907. 8vo. xv+ 589 pp. Price, $2.50.

The author states in his preface that the chief changes from the preceding edition of this book are made in the chapters on the constitution of benzene and on pyrrole. In treating of the constitution of benzene the three most common formulas, viz., those of Kekulé, von Baeyer, and Thiele are given, with a short criticism of each. The study of nitriles, isonitriles, acids, and their derivatives preceed that of unsaturated compounds such as olefines, acetylenes, aldehydes, and ketones with their more stable absorption products; a reversal of the order of these, that is, considering the unsaturated compounds first, would, in the opinion of the writer, give the student a clearer insight into the nature of these compounds.

Reversible reactions, which in recent years have been found so helpful in describing the phenomena of inorganic chemistry, have received but little attention, being referred to only in the ester formation from alcohol and acid, p. 119, and the polymerization of acetaldehyde by sulphuric acid. In general the book is well written, carefully indexed, and very few errors of subject matter or typography were noticed. A. L. S.

Differential and Integral Calculus, by Daniel A. Murray, Professor of Applied Mathematics in McGill University. Pp. 491. Longmans, Green & Co. 1908.

This text-book consists for the most part of material from the author's "Infinitesimal Calculus." There are changes in the treatment of some topics and additions have been made, especially in the matter relating to indeterminate forms, solid geometry, and motion. There are many notes and references for collateral reading, so that the student may obtain fuller information and learn something of the important modern ideas of mathematics. The author has chosen to include only a few problems in the applications of the calculus to engineering and physics. Great care is taken that the student may obtain a clear understanding of the meaning of the operations he performs, and in the first chapters the meaning of a derivative is brought out clearly by solving a number of simple, practical problems. The chapter on the applications to motion is especially good, and it will give the student an exact understanding of speed, velocity, acceleration of a point in a straight line, and acceleration of a point in a plane curve. The geometrical applications of integration are well presented; indeed, one must feel on reading this book that he could use it in his class room with excellent results.

H. E. C.

Integration by Trigonometric and Imaginary Substitutions, by Charles O. Gunther, M. E., Assistant Professor of Mathematics and Mechanics in Stevens Institute of Technology, with introduction by J. Burkitt Webb, C. E., Professor of Mathematics and Mechanics in the Stevens Institute. 1907. Price, $1.25 net, by D. Van Nostrand Co., New York. Pp. 79+vi.

The general purpose of the book is to give students an appreciation of the use of imaginaries and series as means suggested by the problems of nature for dealing with nature's problems. The introduction contains numerous suggestions, interpretations, and extensions of meaning of some of the fundamental relations that lie back of a scheme for integrating functions. The author calls his scheme the *triangle method.* It is certainly within bounds to say that students who have been given such a treatment of methods of integration, as this book contains, will have a clearer and more vital hold on the meaning of the processes that are very likely to seem highly artificial, than the customary treatments of the elementary texts on Calculus are likely to beget. The proposed scheme makes graphic many of the transformations employed. The little volume is intended for use as a supplementary manual for any of the standard texts on differential and integral calculus. The teacher of the calculus will find on its pages many pertinent practical suggestions.

G. W. M.

The American College, a study in contemporary education, by Abraham Flexner. 12mo, 200 pages. $1.00 net; postage, 7 cents. The Century Company, New York.

To the person who has all along supposed that the average American college and university was as perfect a piece of educational machinery as is possible for man to make, this book will be an eye-opener.

The author of this book is equipped both by education and experience to write intelligently on this subject. Every parent who is contemplating sending son or daughter to college should give this book a thorough study, as help will be secured which will materially assist in shaping the young person's career.

The author finds many things to criticise, and discusses to some length what he considers to be the weaknesses of our present higher educational system. The educational methods of our higher schools are analyzed from the secondary school to the end of the college course. Much emphasis is placed on secondary school work, as is shown by the following: "The secondary school is the key to the College position: On the vigor and intelligence of the secondary school, the permanent solution of College problems now depends."

The book has six chapters, under these heads: The Problem Defined, The Development of the College, The Functions of the Modern College, The College and Secondary Education, The Elective System, Graduate and Undergraduate, The Way Out.

The book is well bound and printed in heavy-faced type, making it easy to read. C. H. S.

The Collected Mathematical Papers of James Joseph Sylvester, Vol. II, by Mr. H. F. Baker, St. Johns College, Cambridge, by the Cambridge University Press, in Commission of Messrs. G. P. Putnam's Sons, New York. Price, $6.00.

This second volume of Sylvester's collected papers comprises over 700 pages of the great mathematician's lectures, and an appendix containing much of the correspondence between the author and the leading savants of his time concerning points treated in the lectures. We can not take space in this journal for a full discussion of the merits of this great work, further than to indicate that it contains one hundred and ten important papers of this most versatile mathematical genius, and that every paper will be found of extraordinary interest to advanced students of mathematics, whether their special work lies in the field of geometry, theory of numbers, differential calculus, applied mathematics, astronomy, or general algebra. American students of mathematics will not soon forget the great wave of mathematical interest set going several years ago in this country by Sylvester when he was in the universities of Virginia and Johns Hopkins. This volume of papers will accordingly be very welcome to American students. The excellent form in which the papers are gotten up, the care and insight with which they have been edited, and the reasonable price of the book can scarcely fail to insure large sales among us. Teachers of secondary mathematics will find in this volume numerous sources of interest and stimuli for independent mathematical research that will make them more wide-awake, more alert, and more efficient professionally.

G. W. M.

Practical Elementary Algebra, by Jos. V. Collins, Professor of Mathematics, State Normal School, Stevens Point, Wis. Pp. 415. $1.00. American Book Co., 1908.

The author has planned to make a very simple presentation of algebra, so that the pupil will have a minimum amount of difficulty

in learning the subject, and yet at the end of the course have a rather thoroughgoing knowledge of it. Thus both fractional and literal exponents are reserved for the last half of the book. The attempt is made to hold the interest of the pupil by scattering problems, including interesting informational and vocational ones about thirty or forty pages apart throughout the book, commencing with the first page. Moreover, material for graphical work is distributed about sixty pages apart commencing about the hundredth page, though the author points out in the preface that the graph matter can be introduced earlier if the teacher prefers. The informational problems are meant to be out of the ordinary in that there is a point to many of them. Thus one problem distinguishes between wealth in money and other wealth. (P. 40). The lists of practical problems include many good problems in mensuration, geometry, dietetics, manual training, arithmetic, engineering, etc. One feature is the way in which the author has followed the Herbartian steps in the presentation of topics. He gives first one solution, following it with exercises. Next he asks the pupil to make a rule from his experience in solving the exercises. This is followed by more exercises including practical ones when feasible. Another feature is a highly developed plan for proving and checking results; men in business have to check their results, and it is of the greatest importance that the schoolboy should learn to get results that he knows are correct. The historical notes are an unusual feature in an elementary algebra. H. E. C.

Electricity, Sound, and Light, by Robert A. Millikan, Associate Professor of Physics, University of Chicago, and John Mills, Instructor in Physics Western Reserve University. 8vo, cloth, vi+389 pages. Illustrated. List price, $2.00; mailing price, $2.15. Ginn and Company, Publishers, Chicago.

It has almost become a fixed principle in science and mathematics teaching, in secondary schools, colleges and universities, that the instructor who expects to do good work with his classes must have in their hands a text which embodies the ideas and methods of the instructor, in other words, his individuality expressed in words. This thought, undoubtedly, was one of the main reasons which induced these men to have put into type this text.

The book is the culmination of the work which has been given substantially in the above named institutions for several years, and is intended to be covered in one semester of college work. As the authors state, too, "It is the outgrowth of the conviction that in courses of intermediate grade in colleges and universities a real insight into the methods of physics and a thorough grasp of its foundation principles are not readily gained, unless theory is presented in immediate connection with such concrete laboratory problems as are calculated to give the student the necessary basis for his theoretical work. The present course has therefore been built up around a laboratory outline. Nevertheless it represents a complete logical development, from the standpoint of theory as well as experiment, of the subjects indicated in the title."

The book is divided into twenty-eight chapters—sixteen of which are devoted to electricity and magnetism, five to sound, and seven to light. Each chapter is concluded by an experiment bearing directly upon the matter discussed in it. Following the discussion there are thirteen pages of well-selected problems arranged in groups to correspond to the chapters. Seventeen pages are covered with tables of various physical constants used in the book.

The mechanical and press work on the book, as usual with these publishers, is of the very best. The numbered paragraphs, of which there are 215, begin with bold-faced type. The 258 cuts, mostly new, are well executed and placed so that they are not crowded by the reading matter. C. H. S.

A Secondary Arithmetic, by John C. Stone, Michigan State Normal College, Ypsilanti, and James F. Millis, the Francis W. Parker School, Chicago. Pp. 221. Benj. H. Sanborn & Co. 1908.

The present trend in the educational world toward industrial education is giving us new text-books which will make the instruction in all schools more efficient. The teacher of the old school who takes his text-book of former years and drives his unwilling class through the various subjects therein, for the sake of giving them "mental discipline," can not long withstand the demand of the present day that a pupil shall be fitted in school to work efficiently as well as to think intelligently. That this arithmetic was written to meet the demand is shown by the following statement in the preface: "To meet the demands of the times for a rational, practical, secondary arithmetic which sets forth the actual business practices of the day, and just these, and which contains a large collection of the actual problems encountered in the various building trades, shop work, agriculture, etc., the authors have prepared this book. *The book is especially designed to be vocational in its aim.* The part devoted to the commercial applications has been carefully inspected and approved by practical business men. For the material of an industrial nature the authors have gone to men at work in machine shops, in the various building trades, etc. All the problems are direct, real, and practical."

The book is divided into four parts. Part I gives a thorough review of the fundamental processes with whole numbers, common fractions, and decimals. Part II deals with the applications of arithmetic to business under four heads: Accounts—Buying and Selling; Borrowing, Loaning, and Investing Money; and Cancelling Indebtedness. Part III includes Approximate Number; Powers and Roots; Logarithms; Applications of Arithmetic to Measurements; Applications of Ratio, Proportion, and Variation; Graphical Representation of Statistics. Part IV, Supplementary Vocational Problems.

This book is a long move in the right direction, and doubtless goes far enough at the present time. But when teachers have used this book for a few years they ought to be ready for a new edition (let us hope it may be written!), "A Secondary Arithmetic, Laboratory Manual," which shall give the necessary directions for the pupil to secure his own data in the mathematics laboratory and wherever he may find data outside the class room. An examination of this book will show that the problems are *real* in the sense that they are such as are actually met in practical life, in commercial work, and in the various trades. H. E. C.

The New Physics and Its Evolution by Lucien Poincaré, Inspecteur-Général de l'Instruction Publique. Pages xv+344. D. Appleton and Company, New York.

To those interested in the physical sciences this book will prove of unexceptionable value coming as it does from such a distinguished mathematician. His official position in the Republic has enabled him to appreciate the wonderful changes which have recently taken place in the physical sciences; he is therefore abundantly equipped to write as he does.

The use of mathematics is avoided, the subject matter being treated in such a manner that the reader will have no difficulty in understanding it without the aid of other texts. The author does not claim that the book is a complete résumé of everything which has been discovered in physics during the last few years, but discusses only the more important and best understood topics.

The book is divided into eleven chapters, each chapter except the first and last being sub-divided into sections. Chapter I discusses the "Evolution of Physics," beginning with the discovery of the galvanic battery by Volta in 1800. Chapter II, divided into seven sections, has the general heading "Measurements." Under this comes metrology, measurement of length, measure of mass, measure of time, measure of temperature, derived units and measure of energy and measure of physical constants.

"Principles" is the topic of Chapter III. Five sections are here: Section one treats of the principles of physics, followed by principle of the conservation of energy, principle of Carnot and Clausius, thermodynamics and atomism.

Chapter IV considers the "Various States of Matter" under the sub-heads, the statics of fluids, the liquefaction of gases and low temperatures, solids and liquids and the deformation of solids.

"Solutions and Electrolytic Dissociation" is the heading of Chapter V, the sub-heads being solution, osmosis, osmosis applied to solution and electrolytic dissociation.

In Chapter VI the "Ether" is the topic with the sub-divisions the luminiferous ether, radiation, the electromagnetic ether, electrical oscillations, the x-rays and the ether and gravitation. Chapter VII is devoted to a discussion of wireless telegraphy. Chapter VIII takes up the "Conductivity of Gases and the Ions," under the separate headings the conductivity of gases, the condensation of water vapor by ions, how ions are produced and elections in metals. Chapter IX is devoted to "Cathode Rays and Radioactive Bodies," the separate heads being the cathode rays, radioactive substances, radiations and emanation of radioactive bodies and disaggregation of matter and atomic energy. In Chapter X the "Ether and Matter" are considered under the four separate heads, the relation between the ether and matter, the theory of Lorentz, the mass of elections and new views on ether and matter. The concluding chapter is a short one on the future of physics.

There is a complete index of about four hundred names of scientists mentioned in the body of the book as well as a general one of subjects.

The book is well bound and printed, the type clear ten point.

C. H. S.